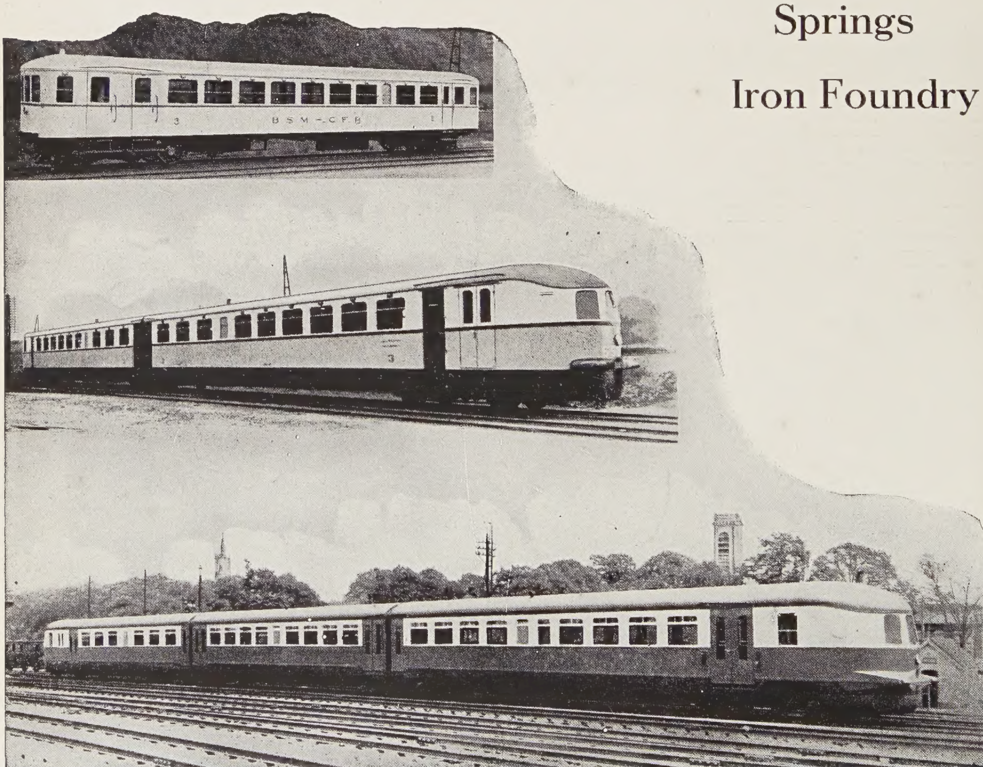
L. XXVII. — No. 4. APRIL 1950.

Monthly Bulletin of the International Railway Congress Association

(English Edition)

STUDIO SIMAR-STEVENS



EADFRAMES AND PITHEAD GEARS
OLES FOR ELECTRIC POWER LINES
ASHOLDERS AND TANKS
RIDGES - STRUCTURAL STEELWORKS
IOULDED AND FORGED STEEL

Electric locomotive - type B.B. - 2200 H.P. - supplied to the Belgian National Railways

COACHES AND WAGONS
MOTOR-COACHES - ELECTRIC LOCOMOTIVES
DIESEL-ELECTRIC OR MECHANIC RAILCARS
PETROL - RAILCARS
LUGGAGE VANS - TENDERS - CONTAINERS

BAUME & MARPENT

SOCIÉTÉ ANONYME

HAINE-SAINT-PIERRE, MORLANWELZ (BELGIUM)
MARPENT (NORTH-FRANCE)

Alphabetical Index of Advertisers

Bulletin of the International Railway Congress Association

CONTENTS OF THE NUMBER FOR APRIL 1950

MONTHLY BULLETIN

OF THE

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

(ENGLISH EDITION)

PUBLISHING and EDITORIAL OFFICES : 19, RUE DU BEAU-SITE, BRUSSELS

Yearly subscription for 1950 : { **Belgium . . . . 700 Belgian Francs** / **Universal Postal Union. . . 800 Belgian Francs**

Price of this single copy : 140 Belgian Francs (not including postage).

Subscriptions and orders for single copies (January 1931 and later editions) to be addressed to the General Secretary, International Railway Congress Association, 19, rue du Beau-Site, Brussels (Belgium).

Orders for copies previous to January 1931 should be addressed to Messrs. Weissenbruch & Co. Ltd., Printers, 49, rue du Poinçon, Brussels.

CONTENTS OF THE NUMBER FOR APRIL 1950.

CONTENTS.	Page.

CONTENTS *(continued)*.	Page.

LIBRARY

OF THE

Permanent Commission of the International Railway Congress Association.

READING ROOM : **19, rue du Beau-Site, Brussels.**

Works in connection with railway matters, which are presented to the Permanent Commission are mentioned in the « Bulletin ». They are filed and placed in the library. If the Executive Committee deems it advisable they are made the subject of a special notice. Books and publications placed in the reading room may be consulted by any person in possession of an introduction delivered by a member of the Association. Books, etc., may not be taken away except by special permission of the Executive Committee.

An edition in French is also published.

Vol. XXVII. — No. 4. April 1950.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[656 .225 & 656 .261]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

15th. SESSION (ROME, 1950).

QUESTION VIII.

In view of the ever increasing weight of road competition, what are the most appropriate measures, apart from reduced rates, for keeping traffic by full wagon loads in the hands of the railway ?

Would not road transport at the end of the railway journey be justified in order to get direct contact with clients who are not connected up by railway sidings ?

Should not the road vehicles required to assure such transport be attached to centre stations, equipped with suitable handling equipment, from which the road transport services would start ?

Choice of the vehicles to be used.

REPORT

(Belgium and Colony, Denmark, France and Colonies, Luxemburg, Netherlands and Colonies, Norway, Poland, Switzerland and Syria),

by GIRETTE,

Chef du Service de l'Exploitation de la Région Sud-Ouest de la Société Nationale des Chemins de fer français.

INTRODUCTION

After a period in which their sole preoccupation was the difficulty of dealing with all the traffic, the railways once more find themselves affected by ever increasing road competition with ample resources available.

This competition operates in a way that makes it quite clear that cost alone does not decide the choice of transport. Other factors, especially speed, saving in handling and packing, and commercial convenience, often play a preponderant part both in the case of goods sent by full wagon loads and the small consignments and parcels traffic.

It is more necessary than ever to make a thorough analysis of all the transport factors,

other than the cost, which the client will take into consideration in making his choice between the railway or road transport.

By means of terminal lorry services the railway can reach clients who are not connected to the railway; the first part of this report will consider whether it is expedient to develop haulage services for full wagon loads under the responsibility of the railway, and how such services should be organised.

There are however other ways of reaching such clients, such as taking the wagons to the consignee by using special trailers or rail-road vehicles, or by using containers. The second part of the report is devoted to the examination of these various means.

Finally, we will recall the part which speed, regularity of transport, use of special wagons, etc., should play in the fight against road competition. This is the subject of the third part of the report.

We sent our questionnaire to 48 Administrations in the following countries : Belgium and Colony, Denmark, France, Colonies and Protectorates, Luxemburg, Norway, Netherlands and Colonies, Poland, Switzerland and Syria.

We wish to tender our sincere thanks to the Administrations who, by their very complete replies, facilitated the preparation of this report :

The Belgian National Railway Company;

The Danish State Railways;

The Luxemburg National Railway Company;

The Norwegian State Railways;

The Swiss Federal Railways;

The Departmental Railway Company (France);

The Algerian Railways;

The Gafsa Railways;

The Tunisian Railway Company;

The Morocco Railways;

The Indochinese Railways Company;

The Damas, Hama and Extensions Railways;

The French National Railway Company.

***

FIRST PART.

It appears extremely attractive in the fight to defend railway transport to encourage the railway services to organise haulage services themselves in the case of goods carried in full wagon loads between the station and the client's premises, or vice versa.

This saves the client the bother of finding a haulier, and above all means direct contact with him, thanks to which the client's requirements and any threat of competition are discovered much more quickly.

The client, in addition to being saved this bother, is assured of a service which will collect his goods on request and with the same transport times, official prices and guarantees that he obtains with a transport contract made with the railway.

And yet in spite of these very great advantages, the terminal transport of full wagon loads by the railway is not very extensive to date. The reasons seem easy to understand. Many clients have their own lorries and think it better to carry out their own terminal transport. Those who make use of public hauliers expect from them certain additional services which a public service cannot foresee in advance and include in its rates. In addition with the services organised by the railway, it is difficult to differentiate the rates in accordance with the importance and quality of the traffic so as to prevent competing private hauliers from taking the cream of the traffic and leaving the less attractive to the railway. Finally, the commercial links which the hauliers have with their clients, are a guarantee of their duration; and since they do not wish to go out of business, any steps the railway may take to fill their place will only set them against it.

The above are the pros and cons for the organisation of terminal road transport for full wagon loads by the railway.

It is not surprising therefore that the replies received to the questionnaire failed to bring out evidence of a choice which many Administrations have not yet explicitely made. As we will see further on, only

two Administrations have organised terminal road transport services on an important scale.

The questions of a general order which this subject gives rise to do not stop here. If it is agreed, that, all things being taken into account, the terminal road services worked by the railway or for which it is responsible, should be extended, a choice must be made between two very different types of organisation :

— either each client is served from the nearest station;

— or the terminal transport services are concentrated at a limited number of stations, which act as centres for the service of all clients within their area.

The first system is doubtless the easiest to put into operation; but it does not diminish the cost of railway transport in any way; and, unless it is to be an additional expense, it must cover all its own expenses by its own receipts.

On the other hand, the concentration of the service into a certain number of centre stations can, it would appear, lead to lower railway costs. Intermediate stations can be closed down. In this way the stopping goods trains will be lightened, speeded up, and their cost reduced. Indirect advantages will also accrue, such as the greater facility in establishing the timetables for the other trains on lines with heavy traffic, reduced shunting costs in making up the stopping trains, etc. Finally the concentration of the haulage services in a single establishment will make it possible to obtain a better use of the stock than when it is dispersed.

Therefore, when making a comparative balance sheet of the two types of organisation, it is necessary to take into account the fact that the road services will be over longer distances, but with a better output from the stock and staff; the possible increase in expense will be made good by a reduction in the railway journey and by the savings obtained by closing down certain stations. Under such conditions it may be that the organisation of haulage services around certain carefully selected centre stations will be the most economic solution.

None of the replies received from the Railway Administrations indicate that they have had occasion to carry out for themselves a thorough comparison between the different possible methods of organisation, so that their choice can be based on a sure foundation. The problem would not appear to have passed beyond the stage of qualitative analysis of the sort outlined above.

It appears that it would be very desirable to make some properly worked out investigations.

In what follows, we have to limit ourselves to reporting the few cases about which we received concrete information.

We have clasified the replies received according to the two types of organisation outlined above.

A. **Terminal transport of full waggon loads to or from the nearest station.**

The Swiss Federal Railways and the Tunisian Railways at the present time are the only ones to assure the terminal transport of full wagon loads at all the stations where it is of interest. In Belgium, the services organised for the terminal transport of small consignments in certain cases also deal with the delivery of full wagon loads

The French National Railways only deliver full wagon loads on behalf of certain public Administrations, for example in the case of the transport of tobacco; in principle therefore they do not carry out the haulage of full wagon loads.

Before the war, they were considering collecting and delivering full wagon loads through their ancillary companies. With this object in view they prepared various haulage rates based on the kind of goods transported; but in spite of their diversity, these rates were not sufficiently flexible for adaptation to all the traffic variations and to all the forms in which traffic of the same kind can be transported. For these reasons,

as well as those outlined in the general considerations given above, the project was not followed up.

None of the other Railways consulted are considering creating a special organisation to assure the terminal transport of full wagon loads at all their stations.

We sum up below the replies received from the Swiss, Tunisian and Belgian Railways, who are the only ones carrying out door to door transport of full wagon loads.

1. *Does the organisation cover all stations and all kinds of goods in full wagon loads?*

In Switzerland the organisation extends to all stations and depots open to traffic by full wagon loads where the need for such a service has been felt. The terminal transport is limited to full loads weighing not more than 5 1/2 t. Only building materials and fuel in bulk are excluded, except for regular transport of such materials under a special agreement.

In Tunisia, haulage is available for full wagon loads at all stations serving towns of a certain size (56 stations out of 136). Practically all goods are covered, except liquid fuels.

In Belgium, full wagon loads can be delivered home at all the stations where door to door services are in operation for the parcels traffic. Certain goods are excluded, such as furniture, goods in bulk, etc.

2. *Development of this organisation since its inauguration.*

Expected development in the future.

In Switzerland, the organisation set up in 1927 continued to develop up to 1947. Since then the traffic has fallen off, owing to the extension of private transport.

The tonnage of full wagon loads collected or delivered represents 5 to 7 % of the total traffic (15 million tons in 1947).

Most of the consignees have their own lorries, so that any great development of the transport of full wagon loads from door to door is not expected.

In Tunisia, the tonnage hauled increased from 50 000 tons in 1938 to 250 000 in 1949, which represents the following percentages :

	Compared with the total traffic	Compared with traffic other than heavy traffic
1938	2.3 %	7.1 %
1949	11 %	25 %

It is hoped that it will increase still further.

In Belgium, terminal haulage services for full wagon loads by the Belgian National Railways are not extensively developed. In the two main centres the monthly average is about :

25 dispatches 150 tons to Brussels;
9 dispatches, 50 tons to Antwerp.

It is practically nil throughout the rest of the country.

3. *Method of carrying out the transport :*

— *by the railway using its own staff and stock;*

— *or by a haulier under contract, giving the method of payment and types of contract.*

In Switzerland, the transport is carried out by so called official hauliers under contract to the Swiss Federal Railways.

They are paid according to the weight carried and the distance.

In certain cases where the rates do not cover the cost, the railway subsidises the official haulier.

In Tunisia, terminal transports are generally carried out by contractors at a price per ton fixed in advance according to the kind of goods.

Part of this transport is however carried out by the Railway with its own staff and lorries to make good the defaulting of hauliers and to keep the rates at a reasonable level.

In Belgium, at Brussels and Antwerp and in some fifty provincial centres, the transport is assured by the railway, using its own staff and stock. The other provincial services are operated by private enterprise and the haulier is under contract and paid a fixed amount per ton delivered or collected.

4. *Details concerning the time taken to collect and deliver from clients premises and the rates charged for these services (kind of rates and price levels).*

In Switzerland, no time is laid down for collecting goods from clients; it is done as quickly as possible. The delivery time only counts from the time the goods, loaded onto a wagon, are handed over to the railway with a waybill. The goods must be delivered home within the delivery time guaranteed by the railway. The charges for collection and delivery are zonal, and are based on the actual weight to the nearest 10 kg with a minimum per consignment.

Contracts are allowed between the official hauliers and clients, provided the rates are lower than the official rates.

In Tunisia, there are no guaranteed times for delivering or collecting goods home; in practice, collections are made to suit consignors and deliveries take place as soon as the wagons arrive.

There are no corresponding haulage rates, the cost of the terminal road transport being included in most cases in the rates for door to door transport which cover both the railway rate and the cost of the haulage services.

In Belgium, delivery home takes place the same day that the wagon arrives at the station; goods are collected not later than the day following the order.

The rates are fixed by weight to the nearest 100 kg with a minimum per consignment.

5. *Data concerning the types of stock used, the average output and per kind of good, and the actual cost.*

In Switzerland, haulage contractors are free to choose their stock. The number and characteristics of the vehicles used varies considerably according to the importance of the services and the extent of the district.

The cost as calculated by the hauliers is checked by the railway when drawing up the official rates.

The railway does not possess any information about the output of such services, but considers that the output of the official haulage services is relatively small.

In Tunisia, according to the kind of goods and the haulage distance, use is made :

— either of horse-drawn vehicles of 1 or 2 tons to carry cereals or flour in the towns;

— motor vehicles of 3 to 5 tons (Railway) to operate the haulage services in the towns or over short distances;

— 7 to 15 t vehicles (Contractors), especially to carry cereals over average or long distances.

The output of the railway vehicles is from 10 to 20 t per day.

The cost of such services in the towns (up to 3 km) varies between 100 and 300 frs. per ton according to the kind of goods and and the sort of vehicle used (horse-drawn or motor vehicles).

For haulage services over longer distances (up to 30 or even 50 km (18 or even 31 miles)), the cost per ton kilometre falls with the distance and varies between 20 frs. and 12.50 frs.

In Belgium, no special stock is used to carry full wagon loads.

6. *Data concerning the financial results of terminal road transport. Does it pay its way or is it subsidised from the railway receipts? If so, to what extent?*

In Switzerland, the haulage rates are fixed so that, as far as possible, the terminal road transport pays for itself.

In Tunisia, as a whole, especially for cereals, the terminal road transport pays its way. However in certain cases, the price of transport by rail has been kept

below that which would have been justified by the increasing costs so that the whole (railway rate plus terminal charges) does not exceed the limit fixed by the prices of competing road hauliers.

To get back certain traffic for the railway, the door to door transport rates are sometimes below cost, varying from the total railway rate plus the normal cost of the terminal charges.

In Belgium, it is considered that the terminal transport of full wagon loads does not pay its way, and costs about 30 % more than the receipts it brings in.

7. *Are clients obliged to make use of the door to door services? Or are they only supplied on demand? Under what conditions?*

In Switzerland, the door to door services are not obligatory and the client is free to ask for all his goods to be delivered home or only part, carrying the remainder himself or by means of private contractors.

In Tunisia door to door services are only worked on demand. No conditions are imposed.

In Belgium, the client must ask for goods to be collected or delivered home.

A full wagon load can only be delivered home if the wagon has been loaded by the railway or if the consignee assists in unloading it.

Clients are able to have part of their traffic delivered home, whilst having the remainder transported by a private firm.

8. *Handling at the station and at client's premises for loading and unloading lorries.*

By whose staff with what mechanical aids?

If the client himself loads and unloads at his premises, how much time is he allowed?

In Switzerland, handling at the station and at client's premises is done by the official lorry drivers themselves or if need be with the mechanical aids provided (cranes, carriers, hand-trucks, block and tackle, etc.).

In Tunisia and *Belgium*, the handling is also done by the lorry drivers or by the Railway when it carries out the transport itself.

No special equipment is used.

9. *What are the main difficulties which had to be overcome to get these services working satisfactorily?*

In Switzerland, the greatest difficulties were :

— standardisation of the rates of the different hauliers in order to create a simple and effective system to fight competition;
— to make sure that the official hauliers does not give priority to certain more remunerative transport, such as furniture removals. and does not exceed the agreed prices;
— in certain cases the impossibility of reducing the costs of the terminal transport sufficiently, so that added to the cost of railway transport, it was in a position to meet road competition.

In Tunisia, it was difficult to prevent the hauliers charging excessive rates. Some of them were in the habit of charging traffic to the station the highest possible rates whilst offering competitive rates for through transport. Some of them have agreed to collaborate with the railway. When they failed to do so, the contractor has been changed, the haulage services being run temporarily by the Railway if needs be.

Difficulties were also experienced in identifying goods, as well as in the handling and make up of loads. Thanks to constant vigilance, there is now no more litigation in the case of door to door transport than in the case of ordinary transport.

In *Belgium*, no special difficulties.

10. *Results obtained. Reaction of railway clients. Attitude of the Public Authorities. Reaction of the public road hauliers.*

In Switzerland, this service is in general appreciated by clients. There has been no

appreciable opposition from the public road hauliers. The Public Authorities have given the necessary licences. Thanks to the door to door services the railway has retained transport menaced by competition which otherwise it would have lost.

The results have been fairly satisfactory but could have been still better.

In Tunisia, the clients are satisfied with this transport. The Public Authorities encourage these services, and the State Departments were amongst the first to use them.

On the other hand the road hauliers are constantly pressing for the Railway to be forbidden to operate its own haulage services and opposing the organisation.

The return to the railway of the whole of the transport of monopoly products (tobacco, tea, salt, etc.) which the road had to a great extent stolen, is due to the organisation of the door to door services serving 40 centres, some of them 200 km (124 miles) from the nearest station.

In Belgium, so far there has been no development of door to door services for full wagon loads. The multiplicity of private transport services and the short distance to the nearest station mean that clients not linked up with the railway can usually manage very well without the additional services offered by the Belgian National Railways.

B. Terminal transport of full wagon loads from certain centre stations.

There is no organisation of the terminal transport of full wagon loads from centre stations on any of the Railways consulted.

Since the 3rd May 1948, for reasons of economy, the Luxemburg Railways have replaced the railway services on certain narrow gauge lines linked up with standard gauge lines by a motor lorry service. In the same way in France, the Departmental Railways have replaced the railway services on certain lines or sections of line of local interest, one of the roles of which was the carrying out of terminal transports, by road services. The S. N. C. F. is going to carry out trials as regards replacing the railway services on certain small lines by a road service, to obtain comparative balance sheets.

Although the problem dealt with by each of these Administrations is not exactly that set out in the questionnaire, we sum up below the information received. As regards the S. N. C. F. it is merely a statement of opinions, since the trials have not yet begun or are only in the premilinary stage.

1. *Choice of stations. — Determination of their sphere of action.*

Luxemburg has adopted as centre stations the junction stations of the suppressed lines and the standard gauge lines.

In the same way, the French Departmental Railways selected as centre stations the old junctions with the main railways.

The S. N. C. F. consider that as the centre station is chosen on account of its geographical position in relation to the line or group of secondary lines to be served, its radius of action should not exceed 50 km (31 miles). In principle the haulage services deal with all kinds of goods.

The Departmental Railways make an exception however in the case of very bulky goods or weighty goods which are too big or heavy for the lorries. In the case of goods for private sidings on the suppressed lines, the S. N. C. F. think it better to retain the railway services when such sidings are close to the junction on the main line.

2. *Methods of carrying out the transport.*

The Departmental Railways carry out the transport with their own staff and road vehicles.

The radius of action is determined by the choice of the transits maintained and the development of the zone of action of the departmental concession.

In Luxemburg, the transport is assured by hauliers under contract to the railway, who are given a fixed sum per km and per

100 kg, including the cost of transport and handling, or a lower rate for the transport and a price per ton varying according to the kind of goods for loading and unloading operations.

The haulier works the service at his own risk and peril and is responsible to the railway for any damage, loss, or shortage after taking over the goods for the road journey or during loading and unloading operations.

The S. N. C. F. consider that the road services should be carried out on their behalf and that they should be responsible from one end to the other; they will make use of hauliers under contract, paid per unit of traffic. The S. N. C. F. will be responsible to clients for all losses, shortages, damages or delays, and the haulier will be responsible for his services to the S. N. C. F.

This responsibility for the transport from one end to the other which the S. N. C. F. desires to have in organising the haulage services around the centre stations is justified by the fact that the risk of losing traffic to road competition is much greater in this case than in the standard organisation of haulage services at each station.

If the organisation of the traffic to the centre station was left to contractors independent of the railway, they would be strongly tempted to take away from the railway such traffic as it would be most remunerative for them or long distance road firms to transport by road over the whole journey.

3. *Delivery and collection times; rates charged the public.*

In Luxemburg the transport is carried out from one end to the other at the rates and conditions in force on the railway. As regards the handling carried out by the contractor, a sum per ton or part ton is charged which varies according to the kind of goods and method of unloading at consignee's premises (by hand or with dumpers).

On the Departmental Railways the delivery time depends upon the regulations concerning the standing of railway stock at the transit station. Collection is assured according to the availability of stock within a period which does not generally exceed 48 hours. The rates are very simple and do not take the kind of goods into account. They can be divided into two headings :

a) kilometric rate loaded or empty;

b) rental on a time basis with a minimum mileage and kilometric rate.

Special season rates and contracts can also be made.

On its side the S. N. C. F. proposes to continue to apply its own rates over the whole journey. A very small surtax will be charged for collection and delivery home in the case of traffic which does not concern either private sidings or rented sites.

4. *Data on the financial results of terminal transport.*

As the services operated in France by the Departmental Railways and in Luxemburg, or under consideration by the S. N. C. F. take the place of suppressed lines, it is impossible to answer the above question directly.

However, the S. N. C. F. consider that the operation of haulage services from centre stations should be more advantageous than services operating from all the stations.

5. *Loading and unloading lorries at the station and at customers premises.*

On the Departmental Railways the handling is done by the railway staff at the station, and at customers premises either by the customer or by the lorry driver against payment. No fixed time is stipulated for loading and unloading the lorries; it must be done as quickly as possible.

The S. N. C. F. expect the loading and unloading of lorries to be carried out in principle :

— at the centre station by the contractors in charge of the road services;

— at client's premises by the clients themselves.

In principle clients will be allowed the same time for loading and unloading lorries as they had for loading and unloading wagons at the station. For this purpose trailers which can be left at client's premises will be largely used.

6. *What are the main difficulties you had to overcome to obtain satisfactory working of this organisation?*

The Departmental Railways report that one of the difficulties is the lack of prevision in the traffic announcements. The transport of full wagon loads was preceded on this Railway by an organisation of the parcels traffic which now facilitates the service since the stock is standardised and interchangeable and it is easier to meet traffic peaks.

The S. N. C. F. is of the opinion that the chief difficulty to be overcome is the necessity to have available at each centre station a very diverse assortment of vehicles so as to be able to carry out all sorts of transport (lorries, dumpers, tank wagons, cattle trucks, etc.), difficulties increased by the considerable variations in traffic which have to dealt with. Each contractor cannot be expected to cope with traffic peaks on his own, so the S. N. C. F. consider that the hauliers responsible for the road services of several sections of line should form themselves into a professional association to guarantee the execution of the service and supply the necessary staff and vehicles to deal with the traffic from the centre station.

7. *Results obtained.*

Luxemburg estimates at 140 000 Belgian francs per km of line suppressed the annual saving obtained by the organisation of road services.

The Departmental Railways also consider that road services are much cheaper to run than the railway whose place they take. The public and the public autorities are in favour of the road services, but the road firms who resent successful competition are definitely against them.

***

SECOND PART.

Although terminal road transport services for which the Railway is responsible is in practice the most general method used to reach clients who are not linked up with the railway, the fact remains that this can never really be door to door transport since it does not do away with the handling of the goods at the station.

Now the importance of having to tranship from lorry to wagon or vice versa becomes greater every day. When road competition began the suppression of such intermediate handling did not seem really essential except in the case of fragile goods, or to reduce or even do away with high packing costs. Today however it is quite clear that any transhipment at a station, which often has to be done by primitive means, consumes a considerable amount of labour, often with a poor output, which makes it very costly. Everything therefore is being done to economise on such handling, even for goods of little intrinsic value, where neither fragility nor cost of packing comes into account : the object is quite simply to reduce the cost of a factor which plays a considerable part in the cost of delivering the goods home.

This old problem is therefore once again a very topical one. The container which proved so successful in the case of furniture or parcels traffic now sees its sphere of action extended by degrees to full wagon loads.

Other methods have also proved their value after extensive experience, both wagon carrying trailers and road-rail trailers. Finally under this same heading we may also include special handling gear intended to link up a station siding with a firm which cannot have its own siding.

By all these methods door to door is assured just as effectively as by road transport : better at times, in so far as the time railway stock can be left at a client's disposal is often longer than that which the road haulier can allow if his rates are not to suffer from the appreciable lowering of the turn round of his lorries.

The development of these various tech-

niques would seem therefore to be of major importance in the fight against road competition. We will now consider the advantages proper to each one of them.

A. Transport in containers.

The use of containers has in the past given rise to a great many studies and publications. Here we will limit ourselves to considering the use of containers for transporting a sufficient tonnage of goods to come under the full wagon load rating.

1. *Do you consider it possible and desirable to develop the use of containers for the transport of goods in full loads?*

If you are already using them, can you give some information concerning the tonnage of transport under the full load rating carried in containers?

Can you show how such transport has grown since first started?

For what kinds of goods is it best suited? What is the percentage of such transport compared with the total transport by full loads?

Can you give any concrete examples of fighting road competition for full loads by using containers?

The Administrations consulted are practically unanimous in affirming that it is possible and desirable to develop the use of the container for transporting goods in full loads.

In Holland this method of transport is continually increasing in importance as the following figures show :

1945 : 14 308 tons;
1946 : 71 141 tons;
1947 : 145 577 tons;
1948 : 242 099 tons;
To end of July 1949 : 170 389 tons.

For some time Switzerland has been carrying out trials with the same type of containers as those used in Holland; the results obtained have been satisfactory.

Belgium has 300 containers (150 open and 150 closed type) under construction, also of the type used in Holland.

Naturally transport by means of containers is used above all for fragile goods requiring careful handling or costly packing (glass, pottery, novelties, papers, furniture, machine spares, etc.) but their use is also being extended to the transport of liquids and powders, and goods in bulk (wine, industrial liquids, cement, coal, lime, broken glass, tiles, bricks, etc.).

In France in particular the use of containers for the transport of wine is becoming very widespread.

In Holland it is considered that the use of containers for full loads is the only effective way of fighting road competition. Switzerland and France have noted many cases in which traffic has been recovered thanks to containers.

Amongst the examples quoted by the S. N. C. F. here are two which seem to be typical. The first concerns the transport over 300 km (186 miles) of cement in bulk intended for the building of a dam, which after being enticed away by the road, returned to the railway thanks to the good turn round of containers each holding 4 to 4 1/2 tons of cement (4 containers per wagon). In all 12 000 tons of cement will have to be carried.

The second example concerns the transport of mineral waters : one supplier appreciates the container which enables him to supply several clients in the same town or nearby very cheaply by loading several containers onto the same wagon, each one addressed to a single client.

2. *Are you extending the use of large containers or special containers?*

The Administrations consulted have not reported the use of containers of more than 5 tons capacity. Such large containers could in fact only be used between stations equipped with the necessary lifting tackle. It would appear better to obtain the greater tonnage by loading several containers onto the same wagon for either one or more consignees.

We give hereafter the characteristics of the containers used at the present time by certain Administrations for full loads.

Owning Railway	Type of container	No.	Tare kg	Internal capacity m³	Maximum useful load kg	Outer dimensions Length m	Width m	Height m
Holland NS	closed	—	1 200	12	5 000	3	2	2
	open	—	900		5 000	3	2.10	1.40
France SNCF	41 open	129	520 to 605	3.4 to 3.7	4 645 to 4 730	2.15	2.15	1.10
	42 closed	689	760 to 1 320	8 to 8.8	3 920 to 4 490	2.15	2.15	2.20 to 2.55
	61 open	131	540 to 605	5.3	4 645 to 4 710	3.25	2.15	1.10
	62 closed	531	930 to 1 750	12 to 13.6	3 500 to 4 320	3.25	2.15	2.20 to 2.55
	82 closed	148	1 200 to 1 450	18.6	3 800 to 4 050	4.35	2.15	2.20

These containers are all fitted with rings so that they can be hoisted by crane.

The Dutch containers are also fitted with runners to make it easier to move and load them. These containers are transported on special wagons equipped with transversal rails (3 containers per wagon).

Holland is not in favour of providing special types of containers. They only possess 27 tank containers for carrying fuel oil (holding 5 1/2 m^3, weight 5 t).

The S. N. C. F. leave it to clients to build any special types of containers or large containers adapted to their special transport requirements.

The development of the use of containers in France, which is very marked in spite of the reduction in the total tonnage carried as full loads, will have an effect on the composition of the stock of wagons, which will have to be very carefully studied.

3. *Do you consider it advisable to extend the use of privately owned containers?*

What steps are you taking to encourage their development?

In Belgium and Switzerland, the Administrations consider the development of privately owned containers a good thing since the capital invested in them will tend to keep their owners faithful to the railways. These Administrations therefore favour this development by granting rating benefits : Switzerland for example carries registered containers free when empty and has simplified the registration formalities.

On the other hand, the Netherlands Railways do not consider it in their interest to develop the use of privately owned containers which seem to them to favour the loss of transport to other transport techniques.

In France, the S. N. C. F. are in favour of and encourage the development of privately owned containers, but recognise that guarantees must be given to make sure that they are not diverted and used on lorries or barges.

In their opinion, clients are better able to build containers exactly meeting their particular requirements than the railway can; special containers ensure the maximum saving of packing and handling.

Transport carried out in privately owned containers benefits by the usual wagon rates reduced by a percentage varying with the distance and type of container used (tank or other than tank).

4. *Have you invented any special gear to handle containers at the stations?*

Do you yourself always carry out such handling at the station? Is the cost included in the cost of railway transport?

Does the client have to cope with the transport of containers between the station and his premises? Or is this always done by the railway? If so, under what conditions? With what vehicles (lorries or trailers left at clients' premises, special gear, etc.).?

In Switzerland, Belgium and France the Railway Administrations leave the handling of containers and their transport between the station and client's premises to the client. In Belgium the use of lifting tackle available at the station is charged for in addition to the cost of the transport.

In France, the S. N. C. F. allow clients to use lifting gear suitable for handling containers free of charge; in addition at certain stations they have provided 5 t motor cranes which can run on the road at a maximum speed of 35 km. h.

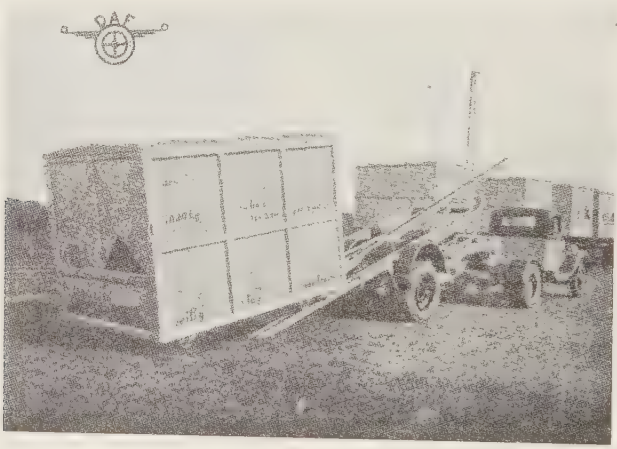


Fig. 1. — Holland. Transfer of a container on a DAF unloader.

In Holland, everything is done for the customer. Handling at the station and at his premises, and transport between the station and his premises are carried out entirely by the railway, which uses for this purpose a tractor and bogie trailer of a special type known as a DAF unloader. These two vehicles make it possible to load or unload the container onto the bogie very rapidly without any other gear, travel at a good speed on the road, and deposit or pick up the container at ground level at the customer's premises. (See fig. 1 and 2.)

These operations are charged for by means of a fee added to the transport rate, the latter being the same for full loads in containers and in ordinary wagons.

The Dutch technique is now being used in Switzerland with the same equipment, experimentally, and will soon be tried out in Belgium.

In Switzerland the first results obtained have proved satisfactory.

5. *What steps have you taken to reduce the cost by avoiding having to load only one container per wagon?*

Are you in favour of grouping containers over the common part of the journey? How do you do so?

In Holland the wagons are designed to take 3 containers : in order to get complete loads, if needs be containers consigned by different consignors are grouped together on the same wagon. If necessary the Railway makes an agreement with clients to favour such grouping. In 1948 on the average 2.3 containers were loaded per wagon.

Switzerland groups containers of the NS type over the common sections of the journey.

In France, the S. N. C. F. favours such grouping by rating measures including the granting of a refund equal to 60 % of the transport rate to firms under agreement with the S. N. C. F. who have signed a fidelity clause, if they consign several containers from different consignees to various consignees on the same wagon and under a single waybill.

In addition, the S. N. C. F. allow an intermediate stop to complete the loading of the wagon at a station near the place of consignment or to take off one or several containers before the final destination.

With such grouping each container is charged according to the rate for the goods it holds under the full load rate; so that if the total tonnage is high, each container will benefit by a corresponding reduction in the transport rate.

This results in a reduction in the cost of transport per ton, and the C. N. C. passes on the saving to the different firms. This saving leads them to increase the proportion of their traffic sent in containers, road transport generally being the loser.

To sum up, the tendency to use containers for transport in full loads is very definite.

The high tonnage, giving a low cost and qualifying for the lowest rates, is obtained not by increasing the size of the container, but by increasing the number of containers loaded on the same flat wagon.

The grouping of containers has proved to be of the greatest interest, making it possible for the consignor of a small tonnage to profit by the rate for a full load when several consignments of containers can be grouped together on the same wagon for the whole journey or part thereof.

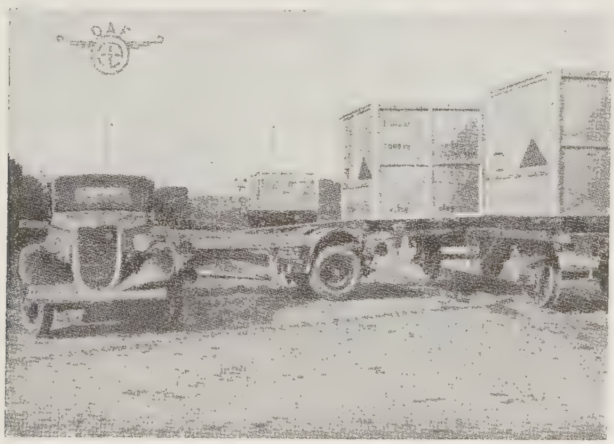


Fig. 2. — Holland. Transfer of a container from a wagon onto a DAF unloader.

To extend such grouping as much as possible, the S. N. C. F. are now profiting by the activities of an ancillary company the C. N. C. (New Container Company). This company operates in the large towns; it gets in touch with all consignors and induces them to co-ordinate their container consigning programmes over the main lines, so that several containers can be grouped on each wagon in a single consignment.

B. **Wagon conveying trailers.**

Since the beginning of the century engineers have devoted much thought to making it possible to take complete wagons into premises not linked up with the railway by private sidings, but no suitable solution has yet been found. In 1931, Mr. BARTHELEMY in France designed a wagon carrying bogie which gave a good

distribution of the load on the ground; this was never taken past the experimental stage however. About the same time, 1933, in Germany, Mr. CULEMAYER designed a wagon conveying trailer which complied with road requirements and could be used with all kinds of axle wagons. Several hundreds of these were built in Germany in the last few years before the war.

Wagon conveying trailers are now used in Switzerland and France. They have not been used by the other Administrations consulted; however in Belgium a private firm is interested in acquiring such vehicles and picking up wagons at the station, and the Danish Railways are studying the matter.

The information given below sums up the replies received from the Swiss (C. F. F.) and French (S. N. C. F.) Railways.

The use of wagon conveying trailers is of special interest in the case of firms of medium size whom it is impossible or too expensive to link up with the railway by means of private sidings.

1. *Complete details concerning particularly interesting examples.*

The two following examples were given by the S. N. C. F.

1. Linking up Caudry Station and the depot of the « Coopérateurs » since May 1947.

Fig. 3. — France. Transfer of a wagon from a wagon conveying trailer onto a moveable track in private premises.

The distance between the station and the depot is 1.8 km. On the way there is a gradient of 3% over 150 m, with a crossing with the main highway where there is poor visibility owing to the presence of a rather low railway bridge. No accidents have occurred since the transport started.

The station installations are of the classic half moon type with a concrete platform to draw up at.

At the Coopérateurs Depot there are several loading and unloading points.

Tracks have been provided at each of these points so that the wagons can be put into position facing the appropriate stores for the goods to be unloaded or loaded (wines, groceries, etc.). (See fig. 3.)

The whole installation has proved completely satisfactory and very labour saving.

The average number of runs between these premises and the station in both directions since the beginning has reached 150 a month, varying between 245 (June 1949) and 79 (May 1947).

The average load per run per month has increased from 123 in 1947 to 155 in 1948 and 181 in 1949.

The total tonnage carried has exceeded 28 000 tons.

The vehicles used (1 tractor and 1 trailer) are still far from being used to full capacity; up to 400 runs a month could be made without working overtime. Owing to the importance of the fixed charges, the cost diminishes very rapidly as the trafic increases, which encourages the client to send the maximum possible by rail.

2. Linking up the Rozena mineral water bottling plant at Rouzat to Pontmort Station.

The 8 km long run is a very difficult one.

On leaving Pontmort Station there is a steep down gradient for more than 500 m; the road is narrow and twisting and ends in a cross roads with poor visibility — the crossing being with a main highway with heavy traffic. Three villages with narrow twisting streets have to be run through before a climb of more than 500 m to reach the bottling plant.

No accidents have occurred however since the service began in July 1947.

At the station the smallness of the unloading yard made it necessary to build a half moon track which involved considerable modifications to the layout of the unloading tracks.

At the Spa, 4 sections of track linked up by a traverser make it possible to accomodate 9 wagons which can be freely shunted from the unloading to the loading points.

The wagon conveying trailer, in spite of the inconvenience caused by the long and difficult run, has made possible considerable economies in the labour required for handling the bottles.

The tonnage transported has reached a total of 33 000 t.

2. *General information on the types of wagon conveying trailers used (dimensions, tare, useful load, load per cm of tyre, lock, time taken for terminal shunting, type of tractors, etc.).*

In Switzerland the wagon conveying trailers used have the following characteristics :

length of chassis . . .	10.05 m (32′11¾″)
width	2.86 m (9′4 5/8″)
height	0.56 m (1′10″)
minimum lock	8.00 m (26′3″)
tare	8 t
load	30 t

100 HP tractors are used, equipped with compressed air brakes.

Two men take 5 to 10 minutes to load and secure a wagon on the trailer.

In France trailers of the Culemayer type in two parts are now used; an improved type of trailer is being manufactured (S. C. E. T. A.-ARBEL).

These trailers have the following characteristics : (See Table on the following page.)

Sometimes 220 HP tractors are used whose size sometimes makes it difficult to manœuvre them, but which are sufficiently powerful to pull particulary heavy loads over long and difficult runs, and sometimes 100 to 150 HP tractors which are sufficiently powerful for most jobs and more practical than the former owing to their smaller size and greater manœuvrability.

3. *Information concerning the limits of use of this method : distance from the station, profile and width of the roads, average daily number of wagons and traffic peaks, station arrangements.*

a) *Distance.*

The C. F. F. consider that the radius of usefulness of the wagon conveying trailer should not be more than 4 km.

	Culemayer 2 part (16 wheels)	S. C. E. T. A. — ARBEL 16 wheels
Dimensions { length	open 13 m 60 closed 6 m 60	8 m 800
Dimensions { width	6 m 75	3 m 10
Rail level	0 m 57	0 m 40
Tare	8 t 5	10 t
Useful load	40 t	40 t
Max. load per cm of tyre	120 kg	125 kg
Radius of lock	7 m 50 to 11 m	8 m 50
Kind of wagons that can be carried	All 4 wheeled wagons with a wheelbase less than 8 m.	All wagons whatever the number of wheels, provided the outer wheelbase is under 8 m.
Time taken for terminal shunting	10 minutes	6 minutes

The C. F. F. only use it in exceptional cases for greater distances than this, in the case of special transport such as that of large transformers.

The S. N. C. F. consider that, taking into account the maximum speed of haulage (20 km, [12 miles] /h) the time taken for the terminal shunting, and the necessity to carry as high a number of wagons as possible to reduce the cost of the transport, the length of the run may be up to 10 km.

b) *Travelling.*

In France, such trailers can travel on nearly all the roads and the problems occasioned by running through certain towns and manœuvring at clients premises have nearly always been successfully solved after careful study. The trailer lock is such that it is possible for it to run into premises through a 5 m gate from an 8 m wide road.

In Switzerland, the trailers run regularly on roads and streets only 6 m wide.

c) *Number of wagons carried.*

In Switzerland, the trailers carry an average of 4 to 5 wagons a day. A daily average of 10 wagons can be obtained at peak periods.

In France, the S. N. C. F. consider that in an 8 hour working day the maximum traffic worked by a trailer can amount to :

18 simple runs if the distance from station to premises is 1 km,

14 simple runs if the distance from station to premises is 3 km,

10 simple runs if the distance from station to premises is 5 km.

Additional traffic can be worked if the working day is increased. The S. N. C. F. mention the case of a gang which succeeded in making 39 single runs in a single day over a distance of 800 m, in spite of the shunting made necessary by temporary installations not very well adapted to such traffic.

d) *Installations at the station and at client's premises.*

In France the usual station installation consists of tracks arranged in a half moon or with a ramp ending in a platform at the height of the rails on the trailer. The end of the ramp track is equipped with gear to shift the rails sideways so that they can be brought exactly in line with the trailer rails. In the case of temporary installations the ramp and platform are replaced by a moveable metal ramp.

At the client's premises, one or several mobile tracks for taking the wagons, which can be moved by hand power, are the cheapest and most practical solution if the amount of traffic is small. If the importance of the traffic justifies it, permanent installations can be provided comparable with those of a railway siding.

4. *Do the vehicles, trailer and tractor, belong to the Railway? Are they operated by the railway, the client merely paying so much per wagon?*

Or are they hired to the client for him to operate at his own expense?

Do certain clients own their own vehicles, and are you in favour of making this the general practice?

In Switzerland, the trailers and tractors belong to the railway, and are operated by it. A trial made of hiring them out did not prove satisfactory.

The rates charged for a trailer are calculated as follows :

1. Basic rate including use for one hour	30	Swiss	fr.
2. Supplement per half hour .	5	»	»
3. Rate per kilometre :			
up to 10 tons	6	»	»
up to 15 tons	7	»	»
more than 15 tons . . .	8	»	»
4. Rebate given if the consignee has a section of line on which to unload the wagon	5	»	»

In France nearly all the trailers belong to the S. C. E. T. A., an affiliated company of the S. N. C. F.

The trailers can be operated in 3 ways :

1. They are rented out on contract to clients who operate them on their own behalf or on behalf of their customers (transport firms).

In this case the responsibility for the transport belongs to the client and the S. C. E. T. A. merely maintains the material and replaces it in case of damage or when taken in for general repairs.

The S. C. E. T. A. make a charge for this based on a fixed sum and a kilometric rate.

2. They are operated by the S. C. E. T. A. according to a contract, generally annual.

The S. C. E. T. A. assumes full control and responsibility for the transport. The client pays a given sum per run made. The rate decreases with the number of runs. The client generally has to guarantee a minimum amount of traffic.

3. They are operated by the S. C. E. T. A. without any contract being made. In this case they are simple haulage services paid for in agreement with the client, according to the tonnage, the number, the wagon, or mileage worked.

Certain clients own trailers. This solution seems to the S. N. C. F. to have certain drawbacks; the traffic of such clients rarely gives the optimum user of the trailers. In addition maintenance and replacement in case of damage may give rise to serious difficulties. The operation of the trailers by a specialist organisation therefore appears to be the most satisfactory solution in most cases.

5. *When does the transport of wagons become more economical than haulage services?*

Can you give figures for a certain number of concrete cases, comparing them with the cost of haulage and handling?

In Switzerland as in France, it is considered that the savings that can be obtained thanks to the use of wagon conveying trailers are above all a function of the difficulty of handling the goods transported. The S. N. C. F. state that in the case of goods which it is difficult to handle (bottles, refined sugar, building materials, etc.) or whose transhipment involves special gear (liquids in tanks, goods in bulk, etc.) such trailers are always economical if more than 3 wagons a day are dealt with.

On the other hand in the case of goods which are easily handled (goods in 50 or 100 kg sacks) trailers only result in economies when there are 4 or 5 wagons a day.

Naturally the saving is greater when the trailers can carry out a balanced traffic with wagons arriving loaded and being immediately re-used for further consignments.

In Switzerland it has been found that the cost of transport by means of trailers is usually 1/6 th less than the cost of haulage including handling at the station, and this difference is still greater in the case of 20 t wagons.

In France the S. C. E. T. A. consider that in the most favourable cases, the saving

may be as much as 40 % of the cost of the usual haulage services.

6. *Can the station installations for putting wagons on the trailers be used by anyone?*

If so, is a charge made for its use? If on the contrary their use is reserved for certain clients, what arrangements are made in this connection?

In Switzerland the station installations can be used by anyone free of charge.

In France, this is not yet the case, and the station installations are used either by a single firm or by an agent serving several clients. The user making use of the trailer signs an agreement with the S. N. C. F.

The S. N. C. F. consider that the development of this system will lead to the common user of the installations at certain large stations.

7. *Are the road traffic regulations any obstacle to the use of the wagon conveying trailers?*

In Switzerland and France the running of wagon conveying trailers requires a licence from the Public Autorities in each case.

In France the speed of trailers is limited to 20 km/h by the highway Code.

8. *In your opinion what are the possibilities for development of this system?*

Do you intend to develop it and can you give any figures?

Have you had occasion to use it to keep or recover traffic menaced by road competition?

Switzerland considers that the system could be further developed in several centres without prejudice to the extension of the use of NS type containers which have just been introduced by the C. F. F.

In France, the S. N. C. F. and its affiliated company the S. C. E. T. A. are disposed to extend it as much as possible.

The many requests received from industrial firms would seem to indicate the great possibilities for its further development.

***

To sum up, the wagon conveying trailer seems to be a perfect solution for linking up the railway and an important firm with no private siding. This solution is only economical however when the traffic exceeds a certain level, measured in average number of wagons per day, and rarely less than 10 000 t per year. The more traffic there is the lower the cost of transport.

C. — Rail-road trailers.

Since road competition first started many experts have endeavoured to bring about real co-operation between rail and road. A certain large French firm had the idea of building a type of lorry which could make the maximum use of the railway gauge, with a low power engine, just sufficiently powerful to carry out terminal transport at low speed but such a vehicle would stand idle too long. It was necessary to recognise the fact that one of the chief difficulties of such mixed transport is to secure the lorry on the wagon whilst relieving the weight on the tyres as much as possible during the run.

Inventors tackled this problem and solved it not with a lorry but with a type of semi-trailer which can be coupled up to any kind of tractor. Thus in France two types of trailers came out before the war, specially designed for transport by rail; the UFR and the SEREM-CODER. Trials carried out on a large scale gradually decided the S. N. C. F. in favour of the UFR which has now been perfected.

Of all the Railway Administrations consulted, only the S. N. C. F. appear to use trailers of this kind. The information which follows deals solely with the services assured by the S. N. C. F. with U.F.R. trailers (Union des Transports Ferroviaires Routiers).

The actual name of these trailers shows their value : the trailer can be used at each end of the journey just like a lorry. Consequently it can be used by firms whose activities are specially directed to road

transport. Owing to its special design the U.F.R. trailer can easily be loaded onto a wagon. And if the railway rates are suitable, it becomes cheaper to transport the trailer by rail than by lorry. And thus the two methods of transport can achieve co-operation.

It appears interesting to define today the degree of development attained by this method of mixed transport.

1. *Characteristics of the trailers used. — Tare, useful load, dimensions, speed, road restrictions.*

The trailers now in use on the S. N. C. F. were built by the Société pour l'Union des Transports Ferroviaires et Routiers (U.F.R.) the earliest types of which date back to 1934.

The U.F.R. trailer when running on the road looks like an ordinary semi-trailer which can be coupled up to any type of tractor provided this is fitted with an F. A. R. type of drawbar; this has a balance coupling hook which automatically drops. The carrying wheels of the semi-trailer however have supplementary flanged rims, and the auxiliary wheels which are retractable and fitted on bearing springs, are also rimmed wheels.

When it is to be loaded on a wagon, the trailer runs on the two longitudinal rails with which the wagons are fitted, owing to the arrangement of the rims on the two carrying wheels, and the two auxiliary wheels. It is then slightly raised, so that there is no longer any weight on the pneumatic tyres.

During the rail journey, the trailer is secured on the rails by means of special wedges designed to damp out to a great extent by gravity the longitudinal shocks.

Two types of trailers are in use : the van type and the tank type, the characteristics of which are as follows :

Van trailer (see fig. 4).

Usefull load	6 t
Maximum load	6.6 t
Tare	3.2 t
Capacity	24 m³

Overall size :

Length	5.75 m
Width	2.45 m
Height	2.96 m

A very low frame in welded sections.

Trailing pair of wheels on twin 38 × 8 pneumatic types.

Direct controlled self-tightening brakes.

Coachwork entirely metal, including two sliding side doors and rear door with two leaves and fan.

12 volt electrical installation.

Tank trailer.

Capacity	7 700 l
Tare	3 t

Overall size :

Length	4.75 m
Width	2.35 m
Height	2.40 m

Direct controlled self-tightening brakes.

Cylindrical tank of Martin steel with one or more tanks including :

60 × 70 emptying valve with dip stick;
emptying pipe with gate valve with symmetrical 65 mm coupling;

12 volt electrical installation.

The average road speed of the trailer can be as much as 50 km (31 miles)/h.

Characteristics of the special wagons on which the trailers are loaded and secured.

The wagons used for the transport of the trailers are 12 m long, and can carry two trailers (1). The frame is mounted on 2 pairs of wheels; the wheelbase is 8 m.

The floor is fitted with 2 longitudinal rails which guide the rims of the carrying wheels and the auxiliary wheels of the trailers.

(1) There are also a certain number of wagons designed to take a single trailer.

The end of each of these guiding rails is fitted with an articulated rail element which, after being extended and locked, gives a continuous track between two consecutive wagons or between the wagons and the fixed end loading dock.

To let the tractors used to shunt the trailers over the buffers each end of the wagon is fitted with two metal supports which bear on brackets fixed to the end sleepers.

Fig. 4. — France. Van type rail-road trailer.

On each side of the wagon is a device for holding the special wedges preventing the trailers from moving.

Thanks to the longitudinal rails and the extensions with which the wagons are fitted, it is possible to load and unload trailers very quickly with complete safety with the minimum labour and without having to shunt the wagons during these operations (see fig. 5).

The wagons whose tare is 10.7 t are fitted with complete air brake equipment.

2. *Who owns the trailers and special wagons?*

The trailers all belong to private firms (haulage contractors for the most part) who have made an agreement with the S. N. C. F. not to use these vehicles on the road except to complete the railway journey, as agreed with the S. N. C. F.

These firms carry out all the negociations with the commercial or industrial firms to obtain the loads; they deal with the handling of the trailers and the terminal haulage for which they have to have the necessary tractors.

To coordinate the movements of the trailers and obtain better utilisation of the stock, Trailer Transport Firms who do not take part in any commercial undertakings which might embarrass the owners of the vehicles, have been set up in the large towns, such as Paris, Lyons and Marseilles.

The wagons equipped to carry the trailers and the other necessary tackles belong to the S. N. C. F.

As the mixed transport developed, it became apparent that close liaison was necessary between the S. N. C. F. and the haulage contractors. A technical organisation known as the « Technical group of mixed rail-road transporters » (G. T. T. M.)

only open to firms owning such trailers, was set up, the chief function of which is to regulate questions dealing with the handling of the trailers at the stations with the S.NC.F.

The function of this organisation is in particular :

— to organise rail-road depots in the large stations which deal with trailers belonging to different haulage contractors;

— to assure at these depots that the trailers are placed on the dock on arrival and loaded into the wagons for despatch, so that the tractors belonging to the firms lose no time and the optimum use of the wagons is obtained;

— to assure the current maintenance of the wedges and inter-connecting gear of the wagons.

This organisation is paid for partly by the haulage contractors and partly by a subsidy from the S. N. C. F.

3. *Rates applied to these trailers and transit times. Special rates.*

The trailers are transported at accelerated timings, with the transit times appropriate thereto.

The transport of the trailers is assured by the railway at a special rate, subject to the proviso that the trailer has first of all been passed by the S. N. C. F. and that the owner of the vehicle has made an agreement with them as regards the terminal road journeys completing the railway journey.

This rate provides two methods of charging loaded trailers :

— a fixed rate resulting from two factors calculated by ready reckoner : one a tonnage charge based on the weight of the goods loaded on the trailer plus a surtax per trailer; this method of payment, which is the most usual, must be specially asked for by the consignor;

Fig. 5. — France. Van trailer being loaded.

— charged according to the nature of the goods loaded, on the net weight of these goods.

Empty trailers are transported at a special rate based on the tare.

4. *Present degree of development. — Number of trailers and wagons in service. — Approximate capital value. — Tonnage transported. — Kind of goods for which this method of transport appears most suited.*

On the 31st July 1949, the total stock of trailers amounted to 633 vehicles and the stock of wagons for transporting these trailers numbered 375.

The traffic carried by rail-road trailers amounted to 91 100 t in 1948, the total receipts (transport loaded and empty) being 192 million francs.

Since the new rates for the transport of these trailers came into force (1st May 1949) and owing to the fact that a certain number of new trailers have been put into service, the traffic has increased very appreciably; thus the tonnage carried during June and July 1949 amounted to 25 670 t compared with 14 400 for the corresponding months of 1948.

Fig. 6. — France. Depot for loading and unloading rail-road trailers.

Held up by the war, the development of rail-road trailers has been very marked in the last few years, and the number of mixed transport firms, which was only 13 in 1947, now is 27; in addition two private firms (« Les Chaussures André » and the « Société La Bakélite ») have equipped themselves with registered rail-road trailers to carry out their own transport.

The traffic worked by rail-road trailers is very varied and consists above all of fragile goods requiring careful packing, for

which as little handling as possible is desirable : window glass, glassware, electrical equipment, footwear, papers and cartons, wines, industrial liquids, milk products, etc.

The use of road-rail trailers, which are particularly suitable for the door to door transport of goods sent in sufficiently large consignments to form, if not a full load for a trailer, at least an important fraction thereof, gives extremely interesting results.

It has been noted that for goods such as window glass and eggs, the transport of which is rarely carried out in ordinary wagons without breakages occurring, absolutely safety is assured when rail-road trailers are used.

5. *Station installations for loading and unloading the trailers.*
By whom are these operations carried out and at what price?

To be able to load and unload the trailers in the stations it is necessary to have an end loading dock 12 m wide and 20 m long (see fig. 6).

The platforms are equipped with special loading gear to assure the automatic centering of the trailer on the centre line of the wagon and to enable the auxiliary rimmed wheels of the trailers to run onto the wagon rails.

This gear, put in front of the wagons to be loaded, consists essentially of entrance guides between which are arranged mobile plates so that if a mistake is made in direction, pulling back the trailer causes it to move sideways which centres it automatically along the centre line of the wagon.

To make sure the rims and auxiliary wheels of the trailer will run onto the rails of the carrying wagon, ramps are placed on the loading gear on the extension of these rails.

Thanks to these arrangements, the loading of a trailer takes about one minute, using the tractor driver alone. Unloading is even quicker.

According to the importance of the traffic, the end platforms are served either by a line or a group of sidings in a straight line sufficiently long to take a whole rake of wagons and assure their intercommunication; in practice the length of the lines should not exceed a maximum of 100 m.

On the other hand in view of the fact that on arrival the trailers can only be unloaded if their drawbar is facing the platform, the large stations are equipped with double direction installations, so that the wagons can be loaded according to the orientation of their destination station, so that on arrival no shunting will be required to get them the right way round.

Loading and unloading the trailers is carried out by the consignors and consignees, the necessary gear being put at their disposal by the S. N. C. F. free of charge.

6. *Radius of action of the trailers.*

To obtain the lowest possible cost, the economics of rail-road transport require the vehicles to be used to the maximum.

To do so, it is necessary that :

— the road journeys made by the trailer to deliver and collect goods should not exceed a certain mileage;
— the load on the trailer should only concern a small number of consignees or consignors, so that the time the trailer is standing idle while goods are being delivered or collected is as short as possible.

The maximum radius of action on the road appears to be 35 km. In exceptional cases the firms use such trailers on collection runs to pick up certain goods, for example eggs or meat.

7. *Probable development of this method of mixed transport as a weapon against public long distance road transport.*

The rail-road trailer is a fortunate combination of the best advantages offered by the railway and by the road.

In addition, it enables road transport contractors to retain their commercial autonomy and continue their activities by giving their clients the same facilities whilst

saving themselves the risks and drawbacks of long distance road transport by benefiting by the regularity and safety of long distance railway transport.

It meets in effect the principles most generally admitted as regards the co-ordination of the two methods of transport which consists in giving the railway the long distance traffic and the road the additional runs required to reach the premises of the consignee and consignor.

In the same way it is, rather than a weapon to fight public long distance road transport, a practical method of co-ordination of road and railway transport, by linking the interests of the railway very closely with those of the road.

The trailers now in service were designed to meet this idea; thus, referring to the clauses of the co-ordination decree of the 12th November 1938, the S. N. C. F. has agreed to participate in the cost of buying such vehicles, setting aside part of the receipts from the traffic which their use has restored to the railway for the amortisation of this cost.

D. — Other methods of liaison with the station.

Apart from the methods which have been described to bring the goods from the client's premises to the station or vice-versa, on most railways there are installations giving direct connection between the premises of private firms and the railways, making it possible to load and unload the wagons at the station and convey the goods mechanically to the premises of the consignee or consignor.

Such installations are of interest when it is not possible to link up the premises with the station by means of a private siding, for geographical or financial reasons; and they may be more economical than the use of one of the methods mentioned above.

Amonst the most currently used of such methods, we may mention :

1. pipe-lines, the use of which is very widespread (386 on the S. N. C. F.) for the transport of liquids (wine, ciders, milk, hydrocarbons, alcohol, etc.);

2. pneumatic transporters for grains and other powder or goods of small dimensions;

3. belt conveyors, and various kinds of conveyors for goods in bulk (tiles, bricks, bottles, etc.) or packed goods (sacks, cases, baskets, etc.);

4. single rails or overhead lines for goods in bulk or packed goods;

5. narrow gauge lines.

The railways find it of interest to facilitate the construction of such private installations which reduce terminal charges and bind the users who have often invested considerable capital therein to the railway.

***

THIRD PART.

In the case of competition between railway and road, there is a very marked tendency to put the question of price in the first place. Yet all the Administrations can see that they are losing certain kinds of traffic although the road rates are definitely higher than those of the railway, because the user is prepared to pay a little more to obtain certain conveniences to which he attaches great importance; we are not thinking of the convenience of door to door transport which has already been examined; what we have in mind is the rapidity of transport and its consequences as regards the importance of the costs for the commerce for goods of high value, the part of collector and sometimes even of treasurer which the road haulier sometimes plays, the exact adaptation of the timetable of the road services to meet the needs of certain activities, etc. Transport by lorries, which encourages frequent small supplies, leads to a reduction in the stocks required; the resulting economies can be very great.

This adaptation to the special requirements of its clients often plays an important part in the preference given to road transport, a part which is all the more valuable to the haulier as his attempts to make his

services more flexible are largely paid for by his clients.

Since this field of investigation is a very vast one and one that could only be covered by a great many special enquiries, we have had to limit our questionnaire to certain essential points.

We will examine the part played by speed and transit times, then that of special materials. And we will conclude by a rapid examination of the facilities offered at stations.

A. Measures concerning transport conditions.

1. *The part played by speed.*

During the last few years what modifications have you made in the classical division of transport into express and slow goods, applicable to all goods at the consignor's choice?

Do you systematically send by express goods without increasing the rates certain goods for which speed is a physical necessity (for example : cattle, early vegetables and fruit, etc.)?

Define your policy to speed up the transport of full loads, in view of the need to meet road competition.

Give examples of progress achieved during the last few years.

All the Railway Administrations consulted are preoccupied with the necessity for speeding up railway transport in order to retain traffic. All of them have taken steps to do so. The methods employed are more or less the same in every case and can now be classified : running through trains to a very close timetable, at night; improving the running of the trains by reducing all unnecessary standing; reduction of stops by a careful study of the timetables, making connections possible, and facilitating these by carefully classifying the wagons whose journey is to be speeded up; choosing the fastest routes even if they are not the shortest, etc.

To these general measures are added others to meet seasonal traffic, such as fruit, vegetables, out of season goods, etc.

But with the exception of the S. N. C. F. all the Administrations consulted have retained the classical organisation with two speeds of transport which the consignor can choose for any kind of goods.

However, most of the Railways have been obliged owing to competition to take measures to speed up certain traffic systematically, especially in the case of cattle and perishable goods. In Belgium for example on the S. N. C. B. cattle and horses are always sent express. In Switzerland and Norway they also are sent by fast trains and even by passenger train without extra charge.

Perishable goods are sent express or by special fast trains at the slow goods rates in Belgium, Luxemburg, Denmark and Syria.

In Switzerland, the slow goods in most cases travel faster today than express goods did in former days.

This all proves how necessary it is to send many kinds of goods by the fastest possible means at the railway's disposal, whilst keeping the rates at the level needed to compete against the road, which is often approximately the slow goods rates for these kinds of goods.

These considerations led the S. N. C. F. in 1946 to modify the conditions under which express or slow goods be selected within the country.

Since that date, goods are transported according to their nature, either « en régime ordinaire » (RO) (ordinary service) when the transit times are comparable with those of the former slow goods, or « en régime accéléré » (RA) (fast service) comparable with the old express goods. The consignor can however demand RA for RO goods if he pays a higher rate. On the other hand RA goods are never sent RO.

Wagons loaded with RA goods are sent by fast parcels trains, which connect up with each other, run no matter how many wagons there are, and are doubled if the traffic makes it necessary.

The RO wagons travel by slower goods trains; regular trains link up the marshalling yards, their number and timetables being

so arranged that at the time of departure there will be a sufficient number of wagons to run at full capacity, any wagons left over being sent by the following train or a special run in the interval.

Goods for which fast transport is a necessity (cattle, out of season goods, etc.) are always sent by the fast service.

Goods for which speed is of prime interest (parcels, grouped goods, furniture, textiles, rail-road trailers, road vehicles, etc.) since 1946 have been sent by the fast service. But, as road competition has become more and more serious since that date, the S. N. C. F. have been obliged to extend the RA services without increasing the rates to certain goods which formerly came under RO.

These modifications can either be extended to cover all the services or only on given services where competition is particularly serious. In this way the importance of the RA transport increases progressively to the limit of the installations required for such traffic and considerations of cost.

The S. N. C. F. state that the organisation of RA transport has contributed to a considerable improvement in the turnround of the stock, to simplified organisation in the stations by amalgamating the express and slow goods offices and depots.

The Indo Chinese Railways have also organised fast and ordinary goods services, but only parcels weighing less than 4 t, perishable goods and livestock are sent RA automatically. The consignors can make their choice in the case of other goods.

The S. N. C. F. gives the following examples of the progress made in reducing the transit times :

Services	Distance in km	Transit time		Difference
		Express 1939 hours	RA May 1949 hours	hours
Tours-Strasbourg	680	34.30	23.30	— 11.00
Bordeaux-Strasbourg	991	44.30	24.55	— 19.35
Bordeaux-Lyon	600	30.30	20.05	— 10.20
Rouen-Strasbourg	621	31.00	23.50	— 7.10
Calais-Nancy	487	36.30	24.07	— 12.23
Perpignan-Versailles	898	38.17	20.18	— 17.29
Avignon-Bennes	919	28.15	26.53	— 1.22
Avignon-Brest	1 168	40.30	34.45	— 5.45
Avignon-Lille	938	25.00	24.14	— 0.45

2. *Actual transit times.*

a) *Have the theoretical transit times been reduced recently owing to competition?*

b) *Give the regulations determining the transit time in the case of express goods traffic.*

In Belgium and Switzerland, the theoretical transit times have recently been reduced. The French National Railways have not made any alteration in the theoretical transit times since the new regime came into force on the 1st January 1946, but on the 1st July 1948 they gave up the additional transit times which they claimed owing to the war damage to their installations and rolling stock. There have not been any recent modifications in the transit times of the other Administrations consulted.

In the case of the express goods services, certain railways (Algeria, Tunisia, Morocco) calculated their transit times on the passenger timetables which normally carry

the express goods,taking it that each consignment should go by the first possible passenger train on condition it was handed in a certain number of hours beforehand.

In Belgium, Holland and Luxemburg, the theoretical transit times for the express goods services are fixed :

— 2 days in Belgium and Luxemburg;

— 24 hours in Italy (temporarily doubled).

On other railways, general transit times are usually calculated per distance of 300 km (one day in Switzerland and on the S. N. C. F. — 12 hours in Denmark) : and increased in case of home delivery (France) or for crossing by ferry boat (Denmark).

c) *In certain cases have you a system guaranteeing shorter transit times than the usual ones? Give all useful particulars, appending the documents by which the public are advised thereof.*

Only the S. N. C. F. state that they allow shorter transit times than the usual ones for certain specified goods forwarded on stated relations by stated trains. Such facility has been extended thanks to the regular organisation of faster trains. The list of the specified relations, goods and trains is brought to the notice of the public at each change of timetables.

None of the other railways consulted guarantees shorter transit times than the usual ones.

However, certain Railways arrange transport plans, available for various categories of goods or all of them, to assure the transport of goods on certain specified services in shorter transit times than the usual ones.

These transport plans are made known to the public on certain Railways (Switzerland) but the latter do not abandon the theoretical transit times.

d) *What new improvements have you under consideration in this field?*

Netherlands believes to abandon additional transit times as soon as possible.

Luxemburg thinks to reduce to one day the theoretical transit time for G. V. (fast goods service) in the very near future.

The S. N. C. F. has the intention to develop as much as possible the services with special transit times.

e) *Are you able to give your clients warning of the arrival of wagons? Indicate the principles upon which your organisation is based in this connection.*

Do you consider this preliminary warning an advantage to the consignee which he will bear in mind if there is competition from the road?

The advice note enables the consignees to organise their works beforehand and to arrange the unloading of the goods within the allowed time to avoid the payment of extra charges.

It was mainly used during the war to speed up the unloading of wagons and get a better turn round of same.

At the present time, certain Railways no longer, make use of it or only in certain cases. Switzerland no longer advises the arrival of goods since the size of the railway makes it possible for goods to arrive within 24 hours. In Belgium, the advice note is only used on certain lines which are served late in the morning. The S. N. C. F. do not send out advice notes in the case of RA wagons as their routing is known in advance so that the consignees know when to expect their arrival.

Advice notes are sent in Morocco and France for RO wagons. In France advice notes are sent by the marshalling yard preceeding the destination station, either by telephone or by special message, so that it reaches this station in time to advise the consignee.

Most Railways consider that the users do not take this advantage into account in choosing the method of transport to be used.

3. *Development of special wagons.*

The advantages of special wagons are well known and appreciated so that there is no point in dwelling on them; their development took place in the past quite apart from any question of competition. It appears however that this is a further reason why the stock of special wagons

should be extended, all the Railways consulted being agreed that these wagons are of the greatest value to the railway when privately owned since the capital invested in them constitutes a close bond between the railway and the client.

From the replies received, the importance of the stock of privately owned special wagons is as follows :

Categories	S. N. C. F.	S. N. C. B.	Luxemburg	Norway	Switzerland	Holland	Algeria	Tunisia	Morocco
Isothermic, refrigerator, insulated	1 104	305			222	270			17
Large size dump wagon, hoppers, skip wagons, covered wagons . . .	6 754	583	83	30		194			
Tank and vat.	27 579	3 528	37	45	1 471 665	901	280 + DC p. wine	41	153
Various . . .	1 550	40	18		189	21			
Total	36 987	4 456	138	75	2 547	1 386		41	170

All the railways appear to be in favour of this development, which they encourage by various means.

In Luxemburg free transport is provided for empty wagons. In Belgium the advantages are given in the form of a rebate per wagon/kilometre and a lower grading for certain goods. In France the rating of privately owned wagons was completely revised in 1948. According to this rating, the S. N. C. F. pays the owner of the wagon a given sum for each journey made loaded, and the owner pays the S. N. C. F. for journeys empty. But, whereas the empty rate formerly exceeded the given sum, the contrary now holds good. The rates and given sums have been so fixed that the capital the owner has invested in the wagons brings in a proper revenue, the higher the closer the ratio between the load and the tare.

However, whilst considering it preferable to leave it to private enterprise to build special wagons at its own expense, several Railways have found it necessary to build some themselves, and operate them either themselves or through an ancillary company.

The motives for this are stated to be as follows :

— to meet the needs of clients whose financial situation makes it impossible (too small a volume of traffic) to build a stock of wagons for their own use, or who do not wish to do so in order to retain complete liberty (Belgium);

— to make good temporary shortages in the stock of certain firms (Tunisia);

— to be able to meet requests to carry out organised bulk transport (Morocco, Tunisia);

— to be able to transport perishable goods under good conditions in their own wagons (Denmark, Norway);

— to put prototypes in service in order to encourage the firms to which they are rented to get similar ones (France).

The French National Railways leaves the operation of its refrigerator and large capacity wagons in the hands of affiliated companies who get a better use out of these wagons than any private firm could, and better than the railway could as it would have less freedom in the matter than the affiliated company. It is the same in Morocco where the isothermic wagons are operated by a Company specialising in this kind of transport which assists the railway in obtaining a traffic for which it is commercially organised.

4. *Other measures.*

Amongst the other measures connected with transport conditions, taken to fight competition, mention must be made of :

a) the facility given to consignors to load goods for several consignees living in places served from the same station in a single wagon (Switzerland and Denmark) or living in two different localities on the same route (Denmark) when the rates for full wagon loads apply;

b) organisation of a service to collect empties at the premises of several clients, which are then grouped together and sent in a single consignment to the same consignee, under whose orders they have been collected (Switzerland);

c) supplying wagons without a preliminary request (Switzerland);

d) the acceptation of consignments outside official hours (Switzerland).

B. **Station facilities.**

Whatever the efforts made to organise door to door services and to extend to an ever increasing extent transport in full wagon loads, the stations as a general rule will still have to deal with the consigning and delivery of these transports, and consequently everything possible must be done to facilitate the client's work. In this connection, the renting of sites in the station precincts is a much appreciated convenience, which completes very usefully the mechanical handling gear provided for client's use.

1. *Sites rented at stations.*

Is this done one a large scale?

Have you become the owner of industrial sites alongside the stations to enable such sites to be rented to railway clients?

All the railways systematically rent any available sites within their property to their clients; none seem to have purchased land adjoining stations to enable them to extend the practice.

Certain Railways lay down that sites rented in this way must be used to store goods received or dispatched by rail. The French National Railways stipulates a minimum annual traffic. Denmark authorises it under condition that the firm renting the site sends all or part of its traffic by rail.

Are you in favour of permanent buildings being erected on such sites?

Do you grant long term leases?

The Railways allow buildings to be erected on the rented sites, except those of North Africa; they are not particularly in favour of permanent buildings; the leases generally include a cancelation clause in the case of long term leases. The period of the lease varies very widely :

Belgium : 15 days to 9 years;

Luxemburg : a few months or 3 to 6 years;

Switzerland : generally less than 15 years;

Hollande : as long as possible;

France (S. N. C. F.) : as long as possible;

Algeria : 20 to 25 years.

The French National Railways authorise the erection of permanent buildings in certain special cases (silos for example). In such cases the cancelation clause is retained but if needs be guaranteeing compensation on a diminishing scale from year to year.

Do your rental charges depend upon the traffic? Are they closely linked with the actual value of the site?

In Belgium, Luxemburg, Switzerland and Norway the rents are based on the actual value of the sites. Belgium and Switzerland also take into account if needs be the traffic of the lease-holders.

In France (S. N. C. F.), in Holland, Algeria and Morocco, the amount of the rent varies according to the importance of the stations which are classified in several groups. The S. N. C. F. bases the rent above all on the traffic of the lease holder, and remits up to 9/10th according to the amount of traffic.

2. *Handling gear available for use by the public.*

The cost involved in handling operations at the stations has impelled all the Railways to modernise their handling gear in the stations. There appears to be a general tendency to replace or double the fixed cranes and gantries which are the most general station equipment by mobile cranes on rubber tyres or caterpillar track which are completely self-contained and can work with automatic appliances.

Without pretending to give a complete list of these new machines, it nevertheless appears of value to mention a few examples reported in their replies by the Railway Administrations.

Fig. 7. — France. Mobile crane used to handle a container.

— Denmark has two cranes on caterpillar tracks with a lift of 1 800 kg used mainly to load timber and machinery.

The charges for using them are based on the ton or wagon. They include driving them with one man. These cranes can be sent to different stations from their base station and no transport charge is made when they are used to load or unload a sufficient number of wagons (6 or 7).

— The Netherlands Railways and the French National Railways rent out mobile cranes with a maximum power of 5 tons.

— In France, some such machines are in use experimentally to handle large consignments and bulk produce with an automatic 500 litres (110 gallons) kibble. As they can travel at a good speed on the road, they can go to client's premises on demand to handle large consignments which have gone or are going by rail (fig. 7 and 8).

— In Holland, the use of these mobile cranes has greatly facilitated the loading of sugar beet into the wagons and made it possible for the railway to retain a traffic often menaced by water competition owing to the greater ease with which vehicles can unload into a barge compared with a railway wagon.

Fig. 8. — Mobile crane with dump bucket.

Before these cranes were put into service the beet wagons were loaded by hand and it took nearly 1 1/2 hours to load a 20 t wagon.

Now the same wagon is loaded in 20

to 30 minutes by a crane using nets holding 1 1/2 to 2 1/2 t of beet which are spread out on the vehicles before they are loaded (fig. 9).

Each crane can handle about 500 t of beet a day.

The cranes are hired with their drivers for the whole period of the beet harvest to the co-operative sugar factories at the stations where the beet will be loaded. The nets are lent by the factory to the growers.

There are no fixed charges for renting these cranes. The Netherlands Railways like the French National Railways consider that the object of providing such machines is not to obtain a direct profit on their work but to retain existing traffic for the railway, or attract new traffic.

Amongst the machines put at the disposal of the public we may also mention the mobile loading ramps used in Holland to load sand or marl into open wagons from the dumper lorries in which it is brought to the station. (Fig. 10). The charge for using these ramps is so much per wagon; they enable a very appreciable saving in the cost of loading to be made.

The S. N. C. F. to facilitate the work of their clients agrees to put at their disposal

Fig. 9. — Holland. Loading a wagon with sugar beet.

for occasional work on payment of a small charge mobile handling or shunting machines such as tractors, or elevateors, which they use for the handling they have to carry out.

RESUME AND CONCLUSIONS.

It must be recognised that the information received from the Administrations to which our questionnaire was sent gave no definite and well-grounded answers to the main

Consequently, we are led in some cases to ask further questions rather than draw up summaries. The summaries are too often the expression of the personal opinion of the reporter rather than a summary of the opinions expressed by the Railway Administrations.

Having made these reservations, we give below a resume of each part of the report, together with the questions and summaries which seem to us to derive therefrom.

Fig. 10. — Holland. Mobile ramp to unload dumpers into open wagons.

point of interest of Question VIII; « would not the extension of road transport at the end of the railway journey to full loads be justified in order to get direct contact with clients who are not connected up by railway sidings? ».

FIRST PART.

The organisation of road transport at the end of the railway journey by the Railway Administrations gives the client the advantages proper to railway transport

(immediate execution, responsibility, official rates); it enables these Administrations to keep in direct contact with their clients and thus be better informed concerning their requirements and any danger of competition. But the flexibility of the services offered by road haulage firms and the considerable amount of transport undertaken by clients themselves in their own lorries militates against extending the railway's activities to the road transport of full wagon loads at the end of the railway journey.

In fact only the Swiss and Tunisian Railways have created such services over the whole of their territory.

These terminal road services can be organised either at all the stations or only in centre stations. No Administration has reported having made a thorough comparative study of the two types of organisation with the supporting figures. No opinion founded upon an economical investigation can therefore be expressed; it would appear desirable to fill in this gap.

The Swiss organisation, created in 1927, continued to expand until 1947, but now appears to be falling off slightly owing to the extension of private transport.

In Switzerland as in Tunisia, terminal transports are worked by hauliers under contract to the railway, who deal with all the handling at the station and at client's premises. In Switzerland, the charges for collection and delivery are added to the transport rate. In Tunisia, they are included in the door to door rate. As a general rule, the rates cover the cost of the terminal transport, but in some cases they are subsidised to meet competition.

No conditions concerning tonnage, nor guarantee of fidelity is required of clients. The main difficulties encountered lay in drawing up uniform rates, and making sure the hauliers respected these rates.

The public is satisfied with the services given, and the Railway thanks to these terminal transports has been able to retain traffic menaced by competition, and in certain cases recover traffic which it had lost.

To the above information based on that supplied by the Railway Administrations, the Reporter wishes to add the following remarks :

Very serious consideration must be given to the fact that private transport (that carried out by the railway client himself in his own vehicles) is extending daily, and appears likely to go on doing so. In passing we may ask ourselves whether this development of private transport to the detriment of public haulage services is not due to a certain failure to appreciate the actual cost and also to the fact that convenience is far and away the most important consideration. However it may be the fact remains that once a firm has its own lorries, it is very improbable that it will make use of the services offered by the railway to carry out its terminal transports; it will nearly always prefer to do them itself, except perhaps at peak traffic periods; but it then becomes a very costly business for the railway. In addition, it appears probable that if the railway adopted a type of organisation based on operation from central stations, closing the small intermediate stations, the clients served by these small stations who have their own lorries would rarely find the saving due to the shorter railway journey made up for the additional haulage costs due to the longer road journey. The mere fact of having to carry out road transport over different distances than the usual ones might lead such clients to make greater use of public long distance road services and perhaps to take steps to carry out their own transport from one end to the other.

Account must also be taken of the fact that the public haulage firms are generally very much against the railway extending its activities to terminal transport; they look upon it as a menace even if the railway does not set up any new undertaking and calls upon the existing hauliers to organise its services. The public hauliers, however, like the railway, are feeling the effects of the development of door to door road transport over medium and long distances, which is taking away much of their business. It would therefore be better to introduce a policy to make the public hauliers side with the railway instead of against it.

For all these reasons I am led to conclude that the development of public and private lorry services in the last twenty years has left the railway very little chance of carrying out any large part of the terminal transport by any services it may organise. If this is true, the value of the measure becomes doubtful, and it would be better to follow some other policy and endeavour to link up the common interests of the public hauliers and the railway. The development of private haulage, whilst not a direct menace to railway traffic, represents nevertheless a possible loss of traffic. A revival of the activity and vitality of public haulage, acting as a brake on private transport thanks to its high quality and low rates would therefore be a very good thing for the railway, which would appear to have a greater interest in favouring the free activity of public hauliers rather than take them under its wing and risk depriving them of part of their flexibility.

This association of the railway and the hauliers is besides conceivable in both types of organisations : in all the stations, or only in the centre stations. However, in the case of road transport around centre stations, the terminal road transport should be done under the control of the Railway, or there is danger of losing traffic.

The choice between the two types of organisation remains an important problem and it is hoped that further studies and particular trials be made in order to bring some more light on this problem, which is still unsolved.

SECOND PART.

Real door to door transport should avoid any transhipment of goods at the two ends of the railway journey. The interest of the methods listed below is due to the fact that they all make it possible to reduce the cost of handling and packing.

A. *Containers.* — Nearly all the railways consider that it is possible and desirable to extend their use for the transport of full loads. The container is already largely used for such transport in Holland and in France, in particular for carrying fragile goods, liquids, powders, and goods in bulk. In general containers holding more than 5 t are not used, and if greater tonnages have to be transported, several containers are grouped together on a single wagon.

France leaves it to the users to load containers and transport them from the station to their premises. In Holland, on the other hand, the railway takes over all these operations from the client. The use of handling gear in the stations is either free or charged for, according to the country.

The value of privately owned containers is sometimes disputed by the Railways owing to the fact that they could be used on lorries or barges. Holland is not in favour of this development. On the other hand, Belgium, Switzerland and France think it desirable and favour it.

B. *Wagon conveying trailers.* — These are now used in Switzerland and France. They have a useful load of 30 t in Switzerland and 40 t in France. They have to be licensed by the Public Authorities. The problems to which they give rise have generally been solved satisfactorily.

The C. F. F. consider that the maximum radius of action of wagon conveying trailers is 4 km while the S. N. C. F. puts it at 10 km.

In Switzerland wagon conveying trailers are operated by the railway. In France they belong to a affiliated company of the S. N. C. F. which hires them out or operates them itself.

The savings which can be made thanks to the use of such vehicles depend above all on the difficulty of handling the goods transported. They also depend on the amount of traffic which must, in general, exceed 4 wagons a day. The installations required at the station and at the client's premises are not very costly.

C. *Rail-Road Trailers.* — These trailers, designed to link up road transport with the railway have been used on a fairly extensive scale in France.

The UFR type trailers are the most usual (van type and tank type); their capacity

is 24 m^3 and their useful load 6 t; two trailers fit on a wagon.

The rail-road trailers belong to private firms. The special wagons used for their transport belong to the S. N. C. F.

The firms owning the trailers are in contact with clients to obtain the freight; they deal with the road transport by means of their tractors. The loading of the trailers onto the wagons and their unloading involves special equipment at the station (end platform). These operations are carried out in the large centres by a specialist organisation.

The trailers are used very effectively to carry fragile goods. It appears desirable not to exceed a radius of 35 km; and the load should only consist of a small number of consignments to shorten the standing time for loading.

The rail-road trailer makes it possible for road transport firms to keep their commercial autonomy, and consequently is a practical method of co-ordination.

D. *Other means.*— On most Railways there are installations linking up private premises to the station and making it possible to unload and load wagons at the station and convey the goods mechanically to the premises of the consignors or consignees. For example: pipe-lines, belt or pneumatic conveyors, runways, aerial lines, narrow gauge lines.

The Railways have an interest in facilitating the creation of such installations which reduce the terminal costs and bind the users, who have often invested considerable capital in them, to the railway.

This review of the characteristics proper to each of these methods makes it possible to conclude that the object assigned by Question VIII « get direct contact with clients not connected up by railway sidings » is fully realised.

The opinion of the Reporter is that these different methods should not be taken as competing against each other; in his eyes each one of them has its own field, and he thinks it better for their use to be developed parallelly.

For goods carried in large quantities, which can profit by the low 20 t rates, the Reporter thinks that the best solution is to take the wagon to the client; if a single client's traffic does not reach the level above which the use of the wagon conveying trailer is economical, it is usually possible to get a sufficient tonnage by grouping together the traffic of several of the important clients of the station.

The rail-road trailer appears to the Reporter to be a very suitable vehicle to take the place of the large 10 to 15 t lorry whenever the load on the lorry is not intended for a single client but includes several consignments of a few tons for several consignees; a very frequent case. By making it possible to exceed the 10 t useful load per wagon (sometimes 15 t), this system makes it possible to obtain the benefit of the high tonnage rates for small consignments grouped on these trailers. The cost of the trailers however makes it essential to have a very fast turn round; for this reason the S. N. C. F. (the only user of the system to date) transports these trailers under the fast goods regime, which moreover is a further attraction for clients, when it is a question of recovering traffic from the road.

The container, the use of which continues to be extended, is certain of further success owing to the simplicity of its structure which makes it possible to reduce the cost of construction, and in the diversity of the capacity offered. While it is difficult to load several consignments of goods onto a single trailer without packing and very careful loading, it is always possible to find a container for each consignment corresponding exactly to its tonnage. The essential problem is then to group these different individual consignments on the same wagon over the whole journey, or over as long a common section as possible. This grouping of containers improves the user of the wagons and results in tonnage conditions qualifying for lower rates. In the opinion of the Reporter a very great effort should be made to increase the number of containers loaded onto each wagon. This grouping of containers can be done either by the railway itself, or by a special Company created for this purpose.

THIRD PART.

The railway should endeavour to adapt itself to the special requirements of its clients; the question of price is not always the deciding factor. It should offer those facilities to which clients attach great importance, such as rapidity of transport, fixed transit times, adaptation of the timetable to requirements, etc.

Rapidity of transport.

All the Railways have taken steps to speed up the transport : running through trains at very close timings, reduction of time lost standing, improvement of connections at junctions, etc.

All the railways consulted with the exception of the S. N. C. F. have kept the classical division of traffic into fast (G. V.) and slow (P. V.) goods at the consignors choice; but most of them have been obliged to speed up systematically certain transports, such as livestock and perishable goods.

In 1946, the S. N. C. F. suppressed the classical division into fast (R. A.) and slow goods (R. O.) and put into force a fast regime and an ordinary regime according to the nature of the goods transported.

Transit times.

Certain railways (Switzerland, Belgium) have reduced these recently.

The S. N. C. F. grants special reduced transit times compared with the ordinary transit times in the case of certain stated goods over stated routes by stated trains.

Advising goods is not considered by most railways to be an effective means of fighting competition.

Special wagons.

All the railways are of the opinion that special wagons are very valuable when privately owned since they attach clients to the railway owing to the considerable capital invested in them.

In general the Railways favour the extension of the stock of privately owned wagons by granting reductions which pay for the capital invested in such wagons.

The Railways themselves own special wagons. Some of them hand over their operation to affiliated Companies, who obtain a better user.

Sites rented at stations.

. All the Railways rent sites within the station premises to clients.

In general, the sites are rented under a long lease and the tenants are allowed to build on them, but clauses concerning the cancellation of the lease generally prevent permanent buildings being erected.

The rents are fixed either on the value of the site, or àccording to the importance of the station in question. Certain railways grant large refunds on the rent in terms of the traffic sent.

Handling gear at the disposal of the public.

Apart from the classical equipment such as derricks and travelling cranes, the Railways have put more up to date equipment into service :

— cranes on caterpillar tracks in Denmark;

— mobile cranes in Holland and France;

— mobile ramps for unloading dumpers into open wagons in Holland.

To end, the Reporter thinks it useful to stress once more the fact that after having dwelt more especially on the comparison between the transport cost, road competition has been able to attract and retain clients less attracted by lower transport costs than by the various facilities offered by the rapidity of the transport, its exact adaptation to essential needs, etc.

The organisation of road transport makes it possible to offer for the door to door transport of consignments of several tons rates that are very little higher than those for large lorry loads. Such conditions favour stocking up frequently in small quantities; which leads to a reduction in the stock required, and consequently lower financial charges.

For goods of a certain value, this advantage largely makes up the difference in

cost between transport by full wagon load and road transport in consignments of a few tons.

It seems certain that the volume of fast goods traffic (G. V. or R. A. in France) will increase ever more and more. But this must not be at the cost of an inadmissible increase of prime cost. The experience of the S. N. C. F. in the case of their fast regime (R. A.) enables the Reporter to state that the new organisation has been a paying proposition, thanks to the reduction in certain elements of the cost (stock in particular) which it has made possible. The increased speed realised has in many cases had a decisive result in the case of competition for long distance transport of fruit and vegetables.

In conclusion, it appears necessary to seek without ceasing in every field any adaptation of railway transport which will enable the user to make in his own sphere of activity such savings as may prove much greater than any reduction in the rates. Such adaptations, which can rarely be made without further complications in the railway services nor without further expense, are however justified if they make it possible to avoid a more important sacrifice in the rates, and this is often the case.

[656 .212 .5]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

15th. SESSION (ROME, 1950).

QUESTION III.

New technical methods adopted for the design and construction of large marshalling yards.

Lay-out and equipment :

Side and importance of siding groups ;
Lay-out of connections at entrance to groups ;
Longitudinal and cross sections ;
Braking installations (Retarders) ;
Control of point (switch) operation ;
Telecommunications ;
Lighting ;
Staff buildings, etc.

REPORT

(Denmark, France and Colonies, Italy, Luxemburg, Netherlands and Colonies, Norway, Poland, Switzerland and Syria.)

by M. MARCHAND,

Ingénieur en Chef au Service Central du Mouvement de la Société Nationale des Chemins de fer français.

The wording of the question on *new* techniques adopted in the construction of marshalling yards may surprise the reader, as in many countries the technique applied in this field is not particularly new. As far as we know, there have not been any remarkable innovations in the marshalling yards built since the war, and the general arrangement of the groups of sidings, the building modalities in plan and section, the braking or sorting apparatus, are the same as before the war, or based on principles perfected during the 1929-1939 period.

It was towards 1929 that marshalling yard technique underwent a profound evolution, owing to the invention of track brakes able to assure powerful braking effects.

However, as questions relating to marshalling yards were last considered at the Madrid Congress in 1930, it is legitimate in the eyes of the International Railway Congress Association to consider as new techniques those tried out or generalised since that time.

The questionnaire sent in August 1949 to the Administrations belonging to the

Association was drawn up on this basis, which was the reason why they were asked to supply detailed information concerning the traffic and layout of marshalling yards built during the last twenty years.

We have faithfully followed the order of the questionnaire in this report, but to avoid encumbering the text, we have merely given the numbers of the questions and not their wording.

I. — IMPORTANCE AND SITING OF THE SIDINGS.

1) *Nature of the different groups of sidings.*

The different operations which can be carried out in a marshalling yard are :

- — the reception of the trains;
- — shunting by direction;
- — marshalling;
- — positioning for departure;
- — the reception of passing trains, to change engines, or to attach or detach wagons.

In small marshalling yards, all these operations are gradually carried out in a single group of sidings. On the other hand, in large marshalling yards, the volume of traffic to be dealt with makes it necessary to divide up these operations amongst several groups, because the number of lines per group is limited in practice, and because it is advisable that the shunting operations be spread over several working places to avoid the shunting engines getting in each others way.

Finally, the use of separate groups of tracks for the main marshalling operations makes it possible to organise the work rationally and facilitates or simplifies in certain cases the carrying out of the different steps; for example the special reception tracks found in all large marshalling yards makes it unnecessary to shunt any rakes into position before shunting them according to direction.

The very large marshalling yards have five sets of tracks corresponding to the basic functions ennumerated above, but many large up-to-date yards are not so completely equipped as this.

The table given in Appendix I giving the characteristics of the traffic and the structure of the marshalling yards built since 1929, shows that the layout of the yards varies a lot as regards the number and size of the groups of tracks used. This variation is naturally due to the fact that each marshalling yard has its individual characteristics from the point of view of the intensity and kind of traffic; for example marshalling yards near main arteries run over by many passenger trains must be able to accept and send out numbers of goods trains in the slack periods between passenger trains; they must therefore have not only ample reception sidings, but also adequate departure tracks. From another point of view, marshalling yards at the ports, near mines, or large industrial centres, most often have to deal with a heavy traffic including a great many through long distance trains, and generally do not need special installations for the formation of trains geographically.

Marshalling yards must therefore be designed individually, taking into account the essential characteristics of the traffic; but other considerations also play their part, such as constructional possibilities, particularly the capital and site available, so that the Departments concerned have to make their choice of the different hypotheses possible, and the solution that is judged to be the best is often a compromise.

For this reason we will limit ourselves in the present chapter to pointing out the general considerations which favour the installation of the different types of sidings, and to examining the advantages or drawbacks of the possible arrangements.

2) *Double marshalling yards.*

To follow the same order as the questionnaire of August 1949, we have to sum up the opinions expressed by the Railways concerning double marshalling yards, con-

sisting of complete installations for reception, shunting and marshalling for each direction of traffic.

Certain Railways formerly constructed double marshalling yards; there are 4 in France, but as Table 1 shows, no double marshalling yard has been built by any of the Administrations who replied to the questionnaire in the last twenty years.

If it is rational to divide up a marshalling yard into groups of sidings according to function, dividing them up according to the direction is much more artificial and leads to many drawbacks : on the one hand, in fact, the output of the two separate installations is generally lower than that of a single yard; on the other hand, except in exceptional cases in which the two directions are totally independent (i.e. in the case of yards at the end of a line such as marshalling yards at ports), exchanges of wagons will have to be made between the two demi-yards and these exchanges are very costly since the wagons involved have to be shunted twice over.

From the replies received, it appears that double marshalling yards were set up between 1920 and 1930 at a time when the technique of marshalling yards was not well developed, and when the output did not exceed 100 wagons an hour.

If the work of a yard exceeded this limit, corresponding to a daily output of 2 000 or 2 500 wagons, it was essential to double it.

Modern shunting equipment, however, makes it possible nowadays to obtain a much higher output; a marshalling yard can in practice deal with 200 wagons an hour, and consequently more than 4 000 wagons a day.

Consequently only in very exceptional cases does it seem necessary to construct a double marshalling yard; generally, it is preferable, from the point of view of capital expenditure and above all of operating costs, to have a single yard, even when there is no exchange of traffic between the two directions of running.

For example, Switzerland reports that the proposals to extend the Bale-Muttenz yard originally considered a double yard, but it is now proposed to deal with any possible increase in the traffic by enlarging the single existing yard.

3) *Marshalling trains. — Formation group of sidings.*

By the expression « marshalling trains » must be understood the whole of the operations involved after shunting, i.e. after collecting together the wagons which will form the train, and these operations differ essentially according to the nature of the trains :

— through trains have to undergo a simple *preparation* during which vans are added, wagons taken off, put in a different order, and have their loads altered, and if needs be rectification of the composition in order to comply with the regulations, which vary from railway to railway but are often very complex, concerning the distribution of the braking of the shunt;

— semi-through trains and stopping trains must be arranged *geographically* in addition, so that the wagons come in the order of the stations served, which involves a complete revision of the composition of the rake.

In many marshalling yards, the formation of trains is carried out :

— either by the shunting hump during periods when shunting according to direction is stopped;

— or at the head of the groups of sidings at the other end to the hump, which we will call in the following pages the « marshalling yard »; for this purpose, one or more humps are provided at the head of the marshalling yard, the classic arrangement being two humps and two adjacent shunting dead end roads (Fig. No. 1). The complexity and low output of

the marshalling operations makes it necessary in fact to devote more shunting engines to this job at certain periods than to the real shunting operations. The installations must therefore be such as will allow of two engines working simultaneously, each on half a group, or a single engine working over the whole group, from one or other of the two shunting roads.

A slightly different solution has however been adopted in France in several yards (Fig. 2); two separate humps are provided each connected separately to each half group of tracks which is usually sufficient as it is very rare to require more than 15 tracks in making up the trains geographically.

This arrangement, which considerably shortens the equipment zone in the marshalling area, makes it possible to improve the output by reducing the shunting time required; a ladder in front of the humps on the buffer stops side gives the necessary connection between the two shunting necks so that exceptional operations involving the whole of the marshalling yard can be carried out.

Groups of tracks specially arranged for making up trains geographically.

Shunting carried out in this way in the marshalling area inevitably causes some interference with coupling up the train engines and the departure of the completed trains; the drawbacks resulting therefrom, which affect the output, are not very serious in the case of simple shunting to make up the trains.

But in important marshalling yards which have to make up a large proportion of semi-through or stopping trains, it is essential to lighten the work of the making up area by installing a specially arranged group of sidings used to arrange the units to be included in trains made up geographically.

As there can be no question of siting the marshalling sidings alongside the reception sidings, owing to the interference this could cause with the shunting area, the only two possible sites are to be found in an extension to or by the side of the marshalling area.

Siting the geographical marshalling group of tracks as an extension to the marshalling area (Fig. 3) has the drawback of increasing the shunting required to transfer the rakes; in addition, the hump is rather far away from the rest of the working area, so that the staff is dispersed which makes supervision and the organisation of the work more difficult.

For this reason, it appears preferable to site the geographical marshalling sidings, when the width of the site makes it possible, by the side of the main marshalling yard (Figs. 4 and 5).

If in certain cases two separate groups of geographical marshalling sidings have been installed, this is generally done so that for each direction of running the ordinary trains may have easy access to the outgoing sidings.

As regards the layout of the marshalling sidings various arrangements are used by the Administrations who replied to our questionnaire.

In Switzerland, the geographical marshalling yard (see Fig. 4) consists of a group of very short sidings on which each rake to be made up is shunted, the wagons for each of the stations served by the train being grouped together on each siding. When this marshalling is completed, the different lots are joined up in geographical order; the trains made up in this way separately one after the other are then sent to the holding sidings to await departure.

In Italy, the geographical marshalling yard also consists of short tracks, but each is a dead end track, which makes it possible to reduce the cost of the installation.

In France, from the point of view of capital expenditure, a yard with long sidings is preferred (Fig. 5); the work of separating the different lots is carried out about the top of the sidings and at the

Typical arrangements of marshalling yards :

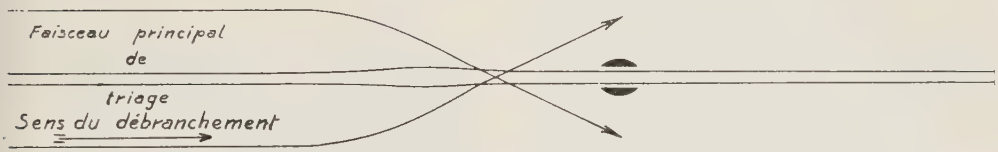


Fig. 1. — Yard with 2 humps serving all the sidings. — Main group of sidings. In the direction of the shunting.

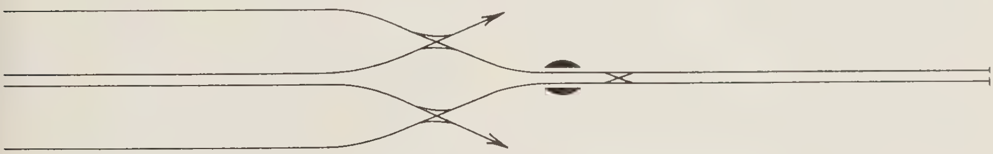


Fig. 2. — Yard with 2 humps each serving half a group of sidings.

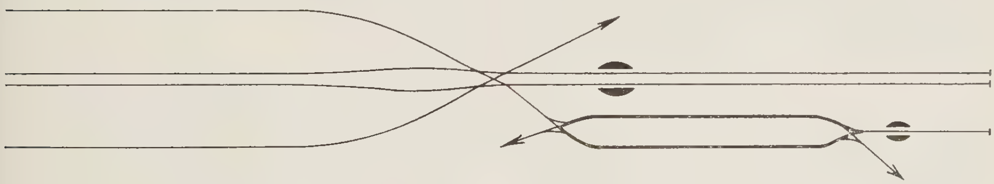


Fig. 3. — Geographical marshalling sidings at the end of the yard.

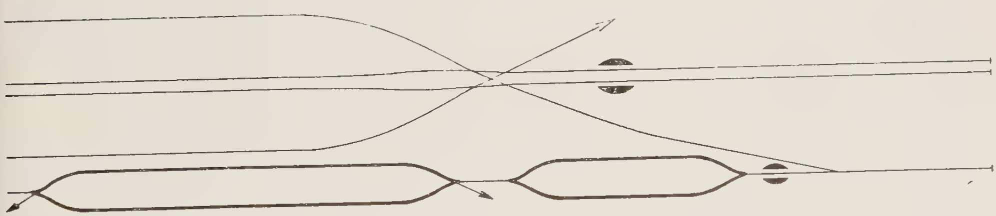


Fig. 4. — Geographical marshalling sidings (Swiss arrangement).

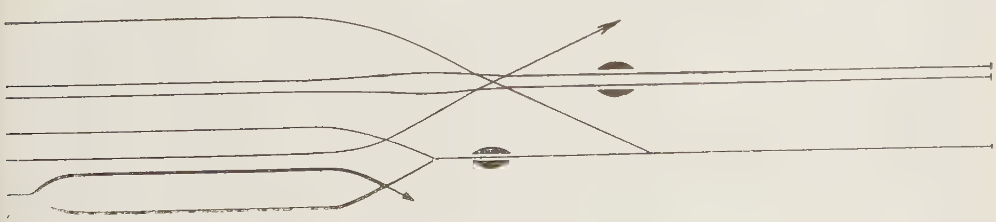


Fig. 5 — Geographical marshalling sidings (French arrangement).

top of the lines adjoining the main group; the bulk of this special group is used as a holding siding for the ordinary trains after they have been made up; this group of long sidings can moreover be used to make up either ordinary trains made up of a large number of small lots, or semi-through trains made up of a few large rakes; it can also be used as a holding siding for the through trains.

France points out that only marshalling yards with long sidings make it possible to apply « *simultaneous marshalling* » [1] which is intended to permit the geographical marshalling of a group of trains by shunting alone, doing away with all the costly and lengthy work of collecting the wagons by locomotives.

In this case, when the shunting engine can be used either wholly or in part for marshalling operations, it is advisable to connect the making up sidings with the shunting hump to profit from the efficient and up-to-date equipment as there is very little difference between the operations involved in « *simultaneous marshalling* » and shunting. The sidings used for marshalling geographically the trains are then incorporated in the main group of marshalling sidings.

4) a. *Departure yard.*

While a train is being made up, then waiting its turn to go onto one of the main marshalling lines, shunting continues :

— if the train must leave in the opposite direction to the shunting, wagons intended for the corresponding line have to be sent back, and picking them up subsequently is always costly;
— if, on the contrary, the train leaves in the shunting direction, the wagons can continue to be sent to the corresponding line, at least while making up is in progress, but this possibility disappears when waiting to leave is prolonged.

In certain cases, these drawbacks can be mitigated by allocating two lines for each of the most heavily loaded directions; when one line is full, the wagons for the corresponding direction are shunted onto the other. But this measure can only be applied to a small extent as it can only be taken for a limited number of directions.

For this reason large marshalling yards are generally equipped with a special group of departure sidings, into which the rakes are shunted as soon as they are ready; it is impossible to stress too much the value of such a group which gives the operating sufficient flexibility of working to keep the shunting work in which so much capital has been invested going at a regular, rapid rhythm.

The existence of waiting sidings for trains ready to leave also increases the flexibility of the Traction Services for supplying engines; the various economies which may result, by making it possible to work on rational lines with a very small stock of engines, i.e. with « low traction » will cover to a large extent the installation costs of these yards as well as the operating costs corresponding to the shunting of trains ready to leave from the marshalling sidings to the departure sidings.

To sum up, it may be stated that it is always an advantage when there is sufficient space available to install a group of departure sidings in up-to-date marshalling yards :

a) to do away with departures in the reverse direction which oblige the shunting yard to send back wagons when making up the trains for departure, and to stop working when engines are put at the head of the trains and when they leave;

b) to prevent obstructing the sidings whilst awaiting departure, especially on Railways working with only a few shunting engines and in yards serving lines with a heavy passenger traffic where the trains

(1) The examination and discussion of marshalling methods is to be dealt with by the reporters of the 3rd section : Question VII (Methods of organisation in the large marshalling and shunting yards).

may have to wait a long time before being able to leave.

Siting of the departure yard.

Examination of the plans sent us shows that it is possible to site the departure yard as an extension of the marshalling yard (Fig. 6) or alongside the main marshalling yard; as a single group (Fig. 7) or on two separate groups, one for each direction (Fig. 8).

The staff required for the departure sidings is very small, so that contrarily to what was said in the case of geographical marshalling yards, there are not the same objections to making it an extension of the main yard; on the contrary locating it in such a situation is rather favourable since the shunting when transferring from the main yard to the departure yard is particularly simple.

On the other hand, as the reply received from Switzerland stresses, it is possible to reduce the size of the installations when the departure yard is sited alongside the main yard, as it can be combined with the geographical marshalling yard.

In our opinion the layout to be adopted for the departure yard depends to a large extent on the site and space available, the best solution for the operating including :

— a combined yard at the side : geographical marshalling;
— awaiting departure, the capacity of which it determined by the output required of the former;
— and a supplementary yard for trains waiting to leave sited as an extension to the main yard.

Note.

Bringing to an end our examination of the questions concerning the marshalling and departure yards, we must make special mention of the arrangements made by the Netherlands Railways to carry out the special conditions of the organisation of their marshalling services.

This Railway points out that each of its twelve large marshalling yards works almost exclusively by night, the work being divided into two distinct periods :

In the evening, each marshalling yard marshals the ordinary trains which collected the wagons of their area, makes up and sends off the through trains to the other marshalling yards.

After midnight, each marshalling yard receives the through trains from the other yards, and makes up from these the trains serving its area, which leave in the early hours of the morning. There is no geographical marshalling of these trains; they merely supply certain large stations in the area, which will serve the neighbouring stations by means of locotractors.

This method of operating, adopted to fight road competition by systematically assuring rapid transit (day A —• day B) makes it unnecessary to have any making up or departure yards.

4 *b*) *Relief sidings.*

Relief sidings are only necessary when through and semi-through trains have to be accepted at the marshalling yard :

— either to change engines;

— or to pick up or leave wagons.

In the first case, the relief sidings can be sited at any point in the yard, the best site being that most easily accessible to the locomotive shed.

In the second case, the relief siding should be sited near the main shunting yard; the best solution as regards the operating is to side the relief sidings alongside the main yard, connecting it up directly with the shunting and marshalling humps, so that wagons can be added or cut off indifferently at either end of the trains.

A relief yard sited in this way (Fig. 9) is in the same position as a side marshalling yard, so that the two can be combined into one later on if needs be. In the same way, the relief yard can be doubled and sited on each side of the shunting yard, with one relief yard for each direction.

Group of sidings for trains waiting to leave and relief sidings.

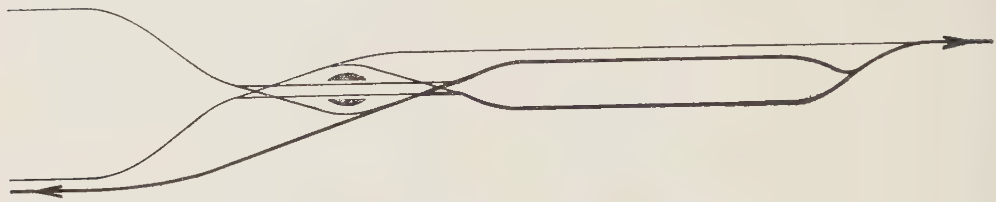


Fig. 6. — End siding for trains leaving.

Fig. 7. — Lateral siding for trains leaving.

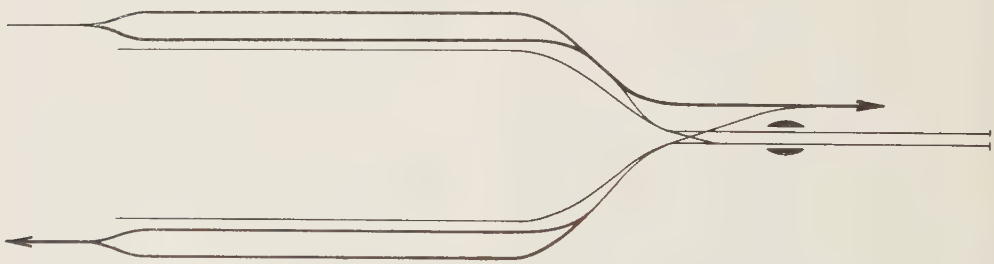


Fig. 8. — Double lateral siding for trains leaving.

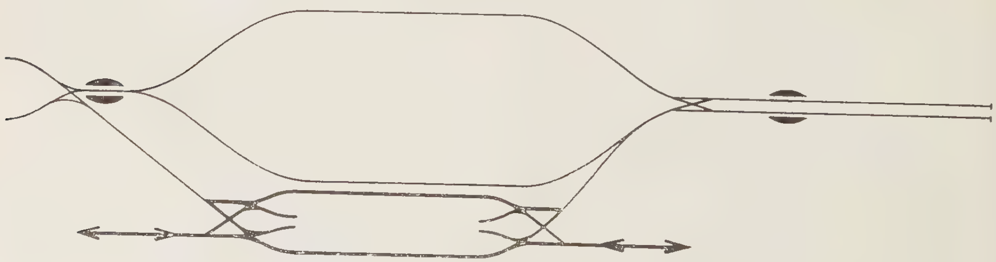


Fig. 9. — Relief siding.

5) *Special equipment for registered wagons.*

In this connection we simply note that France advised us that she has given up transport by registered wagons; as for the other Administrations, they state that they have no special installations for this purpose.

6. *Arrangements to be taken to prevent interference between traffic movements.*

On all railway installations an attempt is made to suppress any interference with the traffic, or at least to diminish the possibility, especially those which are most likely to hinder the smooth running of the services and economy of operation.

Marshalling yard layouts must be closely studied and examined from this point of view :

— in the first place, to prevent any interference between the trains and the shunting, which are a great impediment to the general output of the yard and lead to *lost time* in shunting and making up;

— in the second place, to prevent interference between the trains themselves, so as to keep the traffic circulating satisfactorily in the yard and its neighbourhood, which involves a strict observance of the programme.

The same problems arise in the case of the locomotives used to haul the trains, but to a lesser extent since locomotive movements are quicker and therefore generally less of a hindrance.

a) *Interference of the shunting with the trains.*

Such interference takes place essentially at the ends of the marshalling and reception yards.

As regards the marshalling yards, we have already reported that this can be considerably reduced by the construction of special departure and geographically marshalling yards.

It should be noted however that in large marshalling yards not equipped with these special groups of sidings, it is desirable to have two departure sidings at the head on each side of the shunting sidings, so that a train can always leave one half of the ladder track while shunting is taking place on the other (Fig. 1).

As regards the reception sidings, quite special precautions have to be taken :

— on the one hand, at the opposite end to the hump to enable the shunting engines to get to the end of rakes to be shunted whilst a train is coming in (Fig. 10);

— on the other hand, on the same side as the hump, so that a train from the opposite direction to that of the shunting can be accepted on one half of the sidings whilst a rake is being shunted on the other (Fig. 10).

Another arrangement, more costly however consists in the building of double or multiple turn-outs to deal with most cases of necessary simultaneous marshalling (Fig. 11).

It must however be pointed out that the most tiresome obstruction is that which may occur near the hump between rakes being shunted and trains arriving in the opposite direction; when the arrangements specified above have not been made or are considered insufficient, it is desirable to make the arrival siding for trains arriving in the opposite direction sufficiently long to take the whole train after it has left the main line and is waiting for a shunting operation to finish (Fig. 12); the yard foreman in this way has greater liberty in regulating the shunting and is not obliged to subordinate the shunting to train receptions.

Finally in very large marshalling yards, particularly in yards where at certain hours shunting takes place continuously with two shunting engines working alternately, it becomes impossible in practice to receive on the hump side all the trains arriving in the opposite direction to that of shunting; it becomes necessary in this case :

— either to make one or more backing sidings at the end of the reception yard; trains received on these sidings are propelled back into the reception sidings by the train locomotive (Fig. 13); it should be noted here that it is possible to profit by this arrangement to back a short train onto a short rake already accepted, so that they can both be shunted together in a single operation, which saves an appreciable amount of time, especially when only one shunting engine is available;

— or, which is the best solution from the operating point of view, make a reception loop (Fig. 14), so long as the necessary space is available.

Figs 15 and 16 are diagrams of such an arrangement carried out at Gevrey (France) and Bologna (Italy), the latter yard having been equipped with loops or connections at the entry and exit to the yard, so that all the operations of reception, marshalling and dispatching can be carried out rigorously in one direction only.

b) *Traffic interferences (trains and engines).*

Interference with the traffic can be reduced above all by a rational arrangement of the sidings and running lines.

Any investigation into the layout must be accompanied by a precise determination of the traffic on the different lines and the inevitable crossing points; this enables it to be decided whether it is necessary to spend capital on the construction of flyovers to avoid the most serious cases.

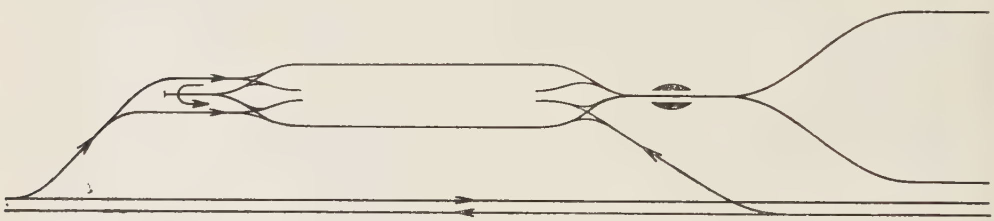


Fig. 10. — Reception of trains divided over two half groups of sidings.

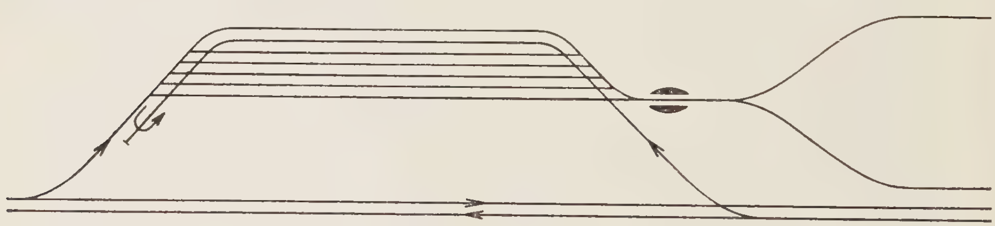


Fig. 11. — Lead in with double turn-outs.

We will merely mention the fact that the itineraries of trains arriving at and leaving a marshalling yard generally cross each other at 3 points, two on the main line and one on the sidings (Fig. 17).

Such points, which are inevitable when the marshalling yard is sited alongside the main line can only be eliminated by flyovers; however, it is possible, as Fig. 18 and 19 show, to lay out the arrival and departure lines in such a way that two such crossings are eliminated by a single work.

Fig. 12. — Reception siding with waiting bay.

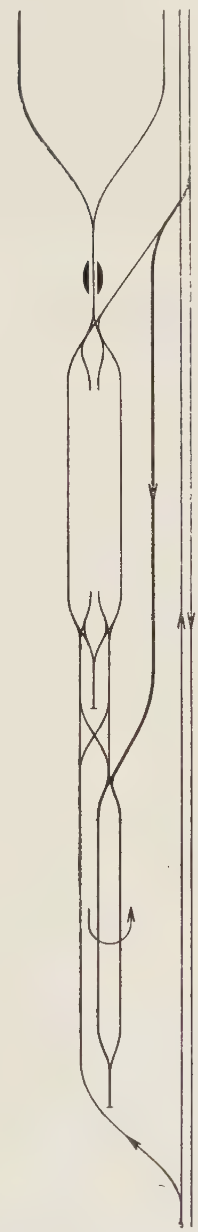


Fig. 13. — Reception of trains by setting back.

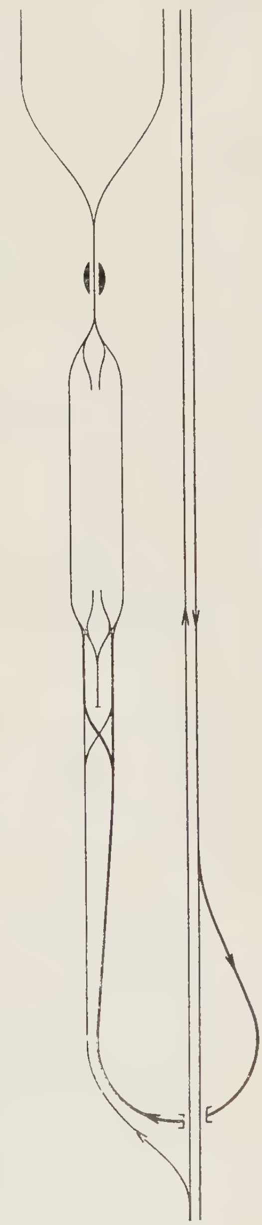


Fig. 14. — Reception of trains through a loop.

The solutions shown in Fig. 18 and 19 differ according to whether this single crossing on the main lines affects the trains received into the yard, or when leaving it; but it is better from the operating point of view to favour the trains received into the yard, which are more likely to get delayed than the trains leaving (Fig. 18). In the same order of ideas it should be noted that the two points of intersection with the main lines are automatically eliminated when the marshalling yard can be sited between two main lines; but this arrangement, which still leaves one point of intersection can only be recommended when the two main lines can be spaced sufficiently far apart.

As regards the circulation of the locomotives, the arrangements to be made depend partly on the site of the locomotive shed; in any case the locomotives leaving the yards to go into the shed on the opposite side cannot cross the shunting areas; the lines must therefore be so arranged that the locomotives can avoid the marshalling yard, either on the side of the reception sidings or on the marshalling yard side (see Fig. 20).

In both cases this is rather a roundabout way, and the lines wil cut across the arrival and departure routes.

To obviate these drawbacks, an interesting solution is to make an underground connection under the shunting hump, as shown in Fig. 20 *b*.

7) *Useful length of the lines and number of lines in the different yards.*

Length of the lines.

The useful length of the lines depends on the length of the trains to be received and made up; it may therefore differ from one yard to another, taking into account for example the profile of the lines served, the power of the traction locomotives, etc.

The useful length may even vary in a yard itself, certain tracks always being used for short trains and others for long trains.

However as the additional cost is relatively little, we think that, apart from certain exceptions justified by local circumstances such as lack of space, when extending existing yards, it is better from the operating point of view to make all the tracks of a ladder track the same length; the staff must in effect take into account a great many considerations in the rational organisation of the shunting and reception and dispatching of trains, and it is better not to impose any additional regulations concerning the choice of track to be used according to the length of the trains concerned.

Moreover, as we shall see later on, the rapidity with which the work is carried out depends on the use of short, homogeneous lead ins groups of sidings, i.e. those whose « *good crossings* » are sited on the same alignment; respecting this condition implies that all the tracks of a group of sidings are the same length.

The length of the tracks of a group of sidings depends therefore in general on the length of the longest trains to be dealt with therein, with a margin over if needs be to assure the necessary flexibility.

In reception or relief sidings, such a margin is not absolutely essential, but it is generally allowed for to prevent trains having to enter slowly and obstructing the points and crossings too long.

On the other hand, in the dispatching sidings, as well as in the comparable marshalling sidings, there does not seem to be any point in having a margin.

In the main marshalling yard, a fairly large margin is necessary, to make it possible to continue shunting on lines where trains are already being made up.

Finally, it should be noted that for the geographical making up of trains a small group of sidings for separating the lots is used (Fig. 4), the length of its tracks depending on the length of the lots (from 100 to 300 m = 328′ 1″ to 984′ 3″).

Number of tracks in the different yards.

The number of sidings must be determined in each case according to the characteristics of the traffic and the programme

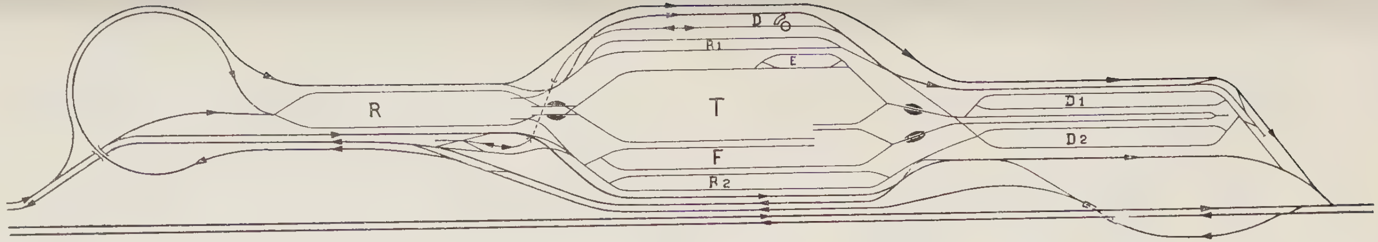


Fig. 15. — Gevrey (France) marshalling yard.

R = Reception. F = Formation R^1 } = Relief D = Depot
T = Marshalling. D^1 — D^2 = Departure. R^2 }

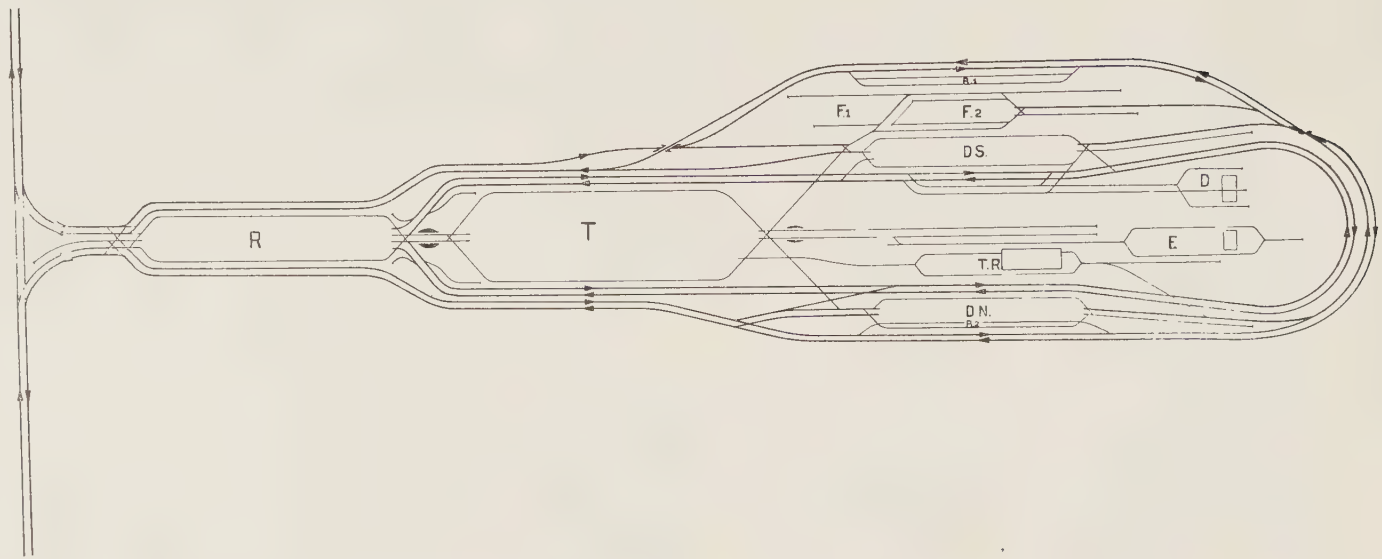


Fig. 16. — Bologna (Italy) marshalling yard.

R = Reception. D.N. = Departure North F^1 } = Geographical formation R^1 } = Relief.
T = Marshalling. D.S. = Departure South F^2 } R^2 }
T. R. = Transhipment. D = Depot.
E. = Maintenance.

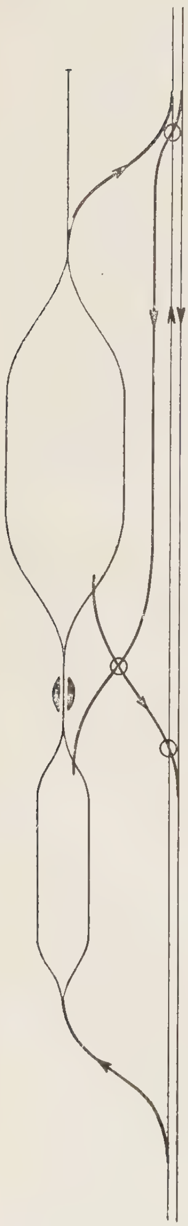


Fig. 17. — Interference between train movements where no flyover is provided.

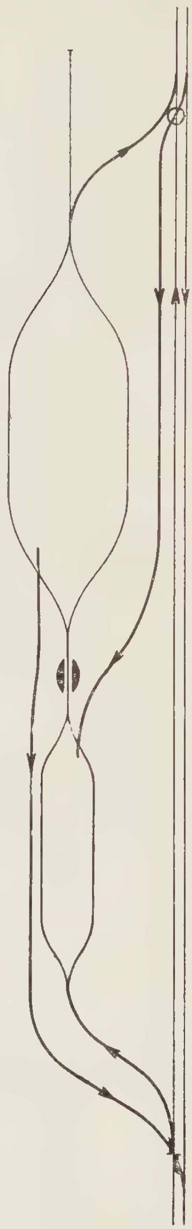


Fig. 18. — Flyover for trains leaving.

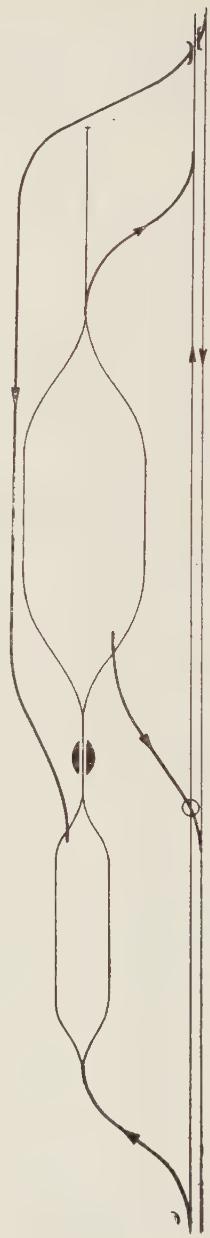


Fig. 19. — Flyover for trains arriving.

of organisation of the work on the line served.

Studies of proposed marshalling yards must therefore be preceeded by a study of the requirements and necessities of the operating.

For example the number of lines in a reception yard depends :

1) on the rhythm at which trains are received, which may be exceptionally high at certain hours in the case of marshalling yards receiving a large number of ordinary trains at the end of the evening, or those situated on lines with heavy passenger traffic where goods trains can only be run at certain times;

2) the time taken for the preliminary shunting operations : inspection and marking, or to be more accurate the number of staff which can be detailed for these operations at the peak periods; Switzerland stresses moreover the importance of the Customs Inspections in the reception sidings at the importing stations;

3) the output in practice from the shunting area;

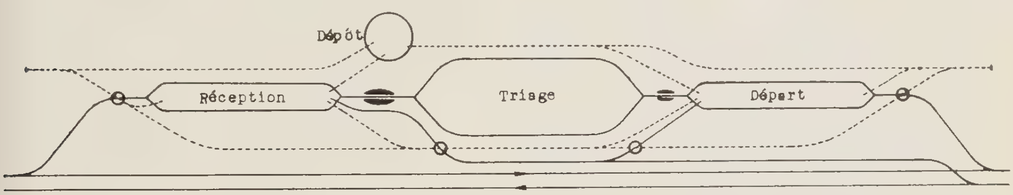
4) if needs be periods during which shunting is stopped, at times when there is little traffic, to make savings in operation.

Similar considerations apply in the case of departure and relief sidings.

As these yards should be large enough to hold the trains which have to remain stationary on them together, taking into account the general operating conditions and the working programme for the marshalling; their size can therefore only be decided by the Operating Department which has to decide what margin will give the necessary flexibility and take into account both the need for reducing the capital invested to the lowest possible figure and yet being able to assure at all times the most economical working conditions.

As regards the main yard, the number of tracks depends upon the greater or lesser selection which the Departments using them wish to obtain after the wagons have passed through the shunting area; for example if empty wagons have to be cut out whose re-use is governed by definite

a) where there is no flyover.



b) where there is a flyover.

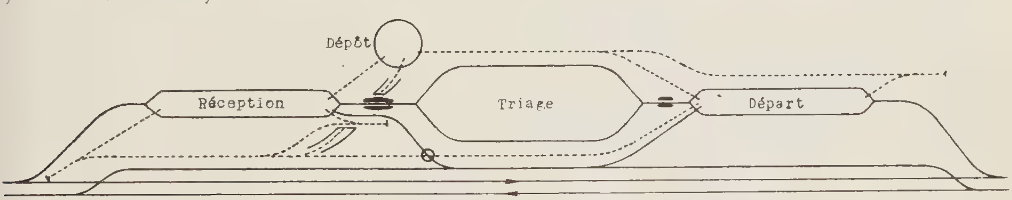


Fig. 20. — Diagram of the engine movements:
Triage = Marshalling ; Depart = Departure.

distribution orders, a track can be provided for each type of wagon : flat truck, covered wagon, dump wagon, however if the number of empty wagons coming in daily is not very great, a single track may suffice, involving of course selection at a later period and the additional cost of the extra shunting involved.

As a whole, from the point of view of the installations, a distinction may be made between :

a) lines reserved for through services, each service having one or several trains daily; a track is necessary for each service, and as we have stated, if there is no dispatching yard, it may be necessary to double the corresponding lines for the services with the heaviest traffic, especially when the trains leave in the opposite direction to that of the shunting;

b) the lines reserved for the local services (empty wagons, made up rakes, loads to be altered, services to the local sheds : depots, tranship sheds, and private sidings). Some of these tracks may be used for several purposes, involving further marshalling or geographical classification later on;

c) making up lines set aside for semi-through and stopping trains serving adjacent lines, the different rakes of which always have to be shunted specially to put them in geographical order.

The number of making up lines is approximately the same whether simultaneous making up or ordinary making up methods are used, so long as the user of the lines is satisfactory in the latter case, for example by grouping together on the same line the wagons for two or more short trains.

But with every hypothesis, whatever the installations and the working methods used, it is always possible to limit the importance of the track equipment by taking the necessary steps to see that the geographical making up of the rakes is completed on the making up lines, at least as far as trains leaving in the direction of the shunting are concerned. The saving obtained by being able to re-use the making up lines as holding lines for trains ready to leave once they have been geographically made up, does not involve any drawbacks for the service, as most of these trains generally leave soon after being made up.

***

II. — LAYOUT AND CONSTRUCTION OF THE GROUPS OF SIDINGS.

It is unanimously agreed that the lead in lines of yards should be very short :

a) in all cases in order to reduce the time they are occupied by shunting trains or engines, and to increase the output of the shunting operations;

b) where gravity shunting is used, in order to reduce the risk of good and badly running wagons catching each other up, and consequently making it possible to shunt at a faster rhythm.

The investigation into the minimum length of the lead in lines depends to a large extent on the layout of the lines and type of equipment used (Fig. 9 *b*), but it must be made when the yard is being designed, retaining only the track equipment strictly necessary for carrying out the services.

The departments using these services are often tempted to provide further connections to give great flexibility *on occasion*, but they must never forget that it is very rare for such additions not to lead to a *permanent* reduction in the output of work.

For example if the double entrances to the reception yard shown in Fig. 11 would seem a priori preferable to the simple arrangement of Fig. 10 owing to the flexibility they give at the time the trains are received, such an arrangement is altogether disadvantageous as regards the shunting output, owing to the extra distance involved.

8) *Study of the connections in the shunting area*

As the shunting area is the most important part of the marshalling yard, it appeared to be of value to ask the opinion of the different Administrations on the various connections which can at times be added to the strictly essential track equipment required for the shunting operations.

a) *Double humps.*

Double humps are those which consist of two lines of humps, on the same level, both serving the whole of the shunting lead in.

When the layout is suitable, such an arrangement only involves an extension of the lead in by some few yards; all the Administrations consequently consider that it is desirable to fit double humps in important marshalling yards, as with them it is possible to use two shunting engines working alternately.

In addition double humps make it possible to shorten the lead in to the reception sidings beside the hump; the designs for the Zurich marshalling yard even include the installation of a triple hump for this reason.

b) and c) *Lines to by-pass the hump and lines to allow trains to leave in the opposite direction.*

Such lines are generally sited at the end of the shunting yard by a common point and crossing placed immediately at the foot of the slope from the hump; and the presence of this point and crossing leads to an increase in the length of the shunting line (of some twenty metres [66']).

There are by-pass lines of this type in many marshalling yards; an examination of the plans we received showed however that some of the large marshalling yards in France, Italy, Holland and Switzerland did not have them.

These lines are intended to take the rakes from the main sidings towards the reception sidings to carry out further marshalling; the rakes in question are therefore long rakes, of considerable tonnage, which the shunting engines could not draw directly over the hump.

These operations are generally carried out when the shunting area has to undertake some of the work of preparing or making up the trains geographically, to fill in periods when there is no shunting. This is often the case in medium sized marshalling yards and sometimes even in the large yards if the traffic falls off.

In our opinion therefore the lack of a track by passing the hump can only be justified in large marshalling yards where there is so much traffic that the shunting area can be expected to be always fully occupied in marshalling.

It must not be forgotten in this connection that the constant increase in wagon loads may result in a railway whilst retaining the same volume of traffic, having less wagons to handle in the marshalling yards, and consequently reducing the time required for shunting properly speaking.

As regards trains leaving in the opposite direction to the shunting, it is generally impossible to avoid this except when the marshalling yard is equipped with a group of sidings for trains waiting to leave.

d) *Double humps for winter and summer.*

Double humps at different levels have sometimes been installed to reduce the height of the fall during the good weather, but the consequences resulting therefore are much more inconvenient than in the preceding cases, since to fit them means increasing the length of the lead in to the reception sidings adjoining the hump by several dozen metres, and consequently increasing the time taken by the shunting engines to bring in the rakes to be shunted from the reception sidings to the shunting hump.

All the Administrations concerned are agreed that this arrangement should be given up, as it is no longer of any practical value owing to the existence of very powerful line brakes capable of absorbing a large amount of excess energy; if needs

be, it is better to use additional brakes on leaving the hump, the reduced length of which will not involve any extension of the layout.

9) *Constructional characteristics of the marshalling yards :*

a) *Groups of sidings.*

It is generally admitted that, except when this is physically impossible, the lines should be made on the straight to facilitate optical communication between employees as well as to give good visibility to the staff manning the points and braking equipment.

Furthermore sufficient six-foot ways must be allowed for the staff (inspectors, pointsmen, brakesmen) to move about in complete safety.

Most Administrations make their six-foot ways of standard width, though a few extra wide ones are provided if necessary for the erection of the electric lighting posts or the electric traction pylons; on the other hand, in France wide and narrow six foot ways are alternated, the latter more especially for the convenience of the staff (with the exception of the inspectors who have to examine wagons on both sides of the lines).

Table 2. gives details of the standards in use on the Railways which replied to the questionnaire, which are all European Railways and have the same gauge for their rolling stock which has a maximum width of 3.15 m (10′ 4 1/32″); however it should be noted that the width of the majority of wagons used on the European Railways does not exceed 3 m (9′ 10 1/8″);

b), c), d) and e) *Marshalling yard lead ins.*

The essential factor in the layout is the *minimum radius* allowed for curves; the length of the lead in is in fact the shorter as this minimum radius is the smaller.

The minimum radius allowed (see Table 2) varies from country to country between 140 to 190 m (459′ 3 3/4″ to 623′ 4 3/8″) but straight sections have to be inserted between curves in opposite directions to prevent the buffers locking.

None of the Administrations have found it necessary to grease the rails on curves of small radius to facilitate the negociation of the curves by the vehicles.

Most Administrations use track equipment of the usual type; only in France is special equipment used on a wide scale consisting of symmetrical very open turnouts with a radius of curvature of 200 m (656′ 2″), the angle of deviation having a tangent of 0.167; these very short switches (18.36 m [60′ 2 13/16″] between the end joints) can be juxtaposed point to heel without any practical drawbacks, thus making it possible to obtain very compact layouts.

The use of switches of this type makes it possible for example to reduce the lead in to a 32 track group to 225 m (see Fig. 21); in addition as all the track equipment is symmetrical, the running resistance of the wagons due to the curves is about the same in the lead in as on the routes taken by the wagons being shunted.

To end this examination of the lead in to a group of sidings, we think it useful to call attention to the two following points :

— on the one hand it is desirable that the different routes taken by wagons shunted near the switches should be of the same length so that there is no risk of their overtaking each other; the realisation of this condition involves siting all the crossings for the lead in to the ladder on the same line, which in consequence greatly facilitates the work of the pointsmen and brakesmen;

— on the other hand it is advisable to reduce to the strict minimum the distance between the top of the hump and the first switch, always taking into account the necessity for suitably spacing the wagons in line with the first switch according to the required shunting rhythm and conditions under

which the points are worked; the replies received on this point which are summed up in Table 2 show that this distance has been reduced to less than 30 m (98′ 5 1/8″).

9 f) *Constitution of the lines in the marshalling yards.*

The track equipment and the ballast characteristics for marshalling sidings may be summed up as follows :

	France	Italy	Luxembourg	Holland	Switzerland
Rails	re-used or new second grade 46 kg rails in the lead-ins	standard rails for service sidings	36 to 46 kg	No. 38 rail	36 to 46 kg rails
Ballast	no regulations	under layer of sand, ballast of broken stone	2-4 cm broken slag	under layer, coarse sand 30 cm deep covering of clinker	under layer of sand or gravel, broken stone ballast

Most Administrations seem to endeavour to make economies in the first cost by using old or second grade rails in the yards.

On the other hand, in the lead ins run over by much traffic and heavy engines, better quality rails are used to reduce maintenance costs.

France reports having extended the use of welding in marshalling yards by the aluminothermic process; the length of the welded rails varying from 120 to 360 m. Apart from the maintenance economies obtained in this way, this process has been found to be of particular value in zones where braking by skids is used; the running surface of the rail being uniform and continuous, the skids hold well and the braking is more regular and more effective.

The kind of material used for ballast varies a lot and appears to depend essentially on local resources; Luxembourg and Switzerland show a marked preference for broken ballast; many Administrations lay an under layer of some permeable material such as sand, gravel, quarry screenings, etc.

France states that when the nature of the soil makes it necessary, drainage is assured by underground drains arranged in herringbone; Luxembourg also makes use of drainage by perforated pipes.

***

III. — LONGITUDINAL AND CROSS SECTIONS.

10) *Marshalling yards on a continuous gradient.*

The principle of marshalling on a continuous gradient at first sight appears attractive as it will do away with the relatively high costs of shunting engines, but in practical application serious difficulties arise which usually make it impossible.

a) If the marshalling and making up is to be done by gravity, whatever the weather conditions, it is necessary to have an average gradient of 8 mm per m ($8\,^0/_{00}$) in the sidings to overcome the running resistance of the worst rolling wagons.

Moreover at least three groups of sidings in the extension of the yard are required to assure the reception, marshalling and making up of the trains; consequently for a yard of 3 groups of sidings each 800 m long, the total fall from one end of the yard to the other will have to be of the order of 25 m. Unless extensive earthworks are made it is therefore impossible to make marshalling yards on a continuous gradient unless the site has the necessary natural slope;

b) The gradients required may be an obstacle to the direct reception of heavy

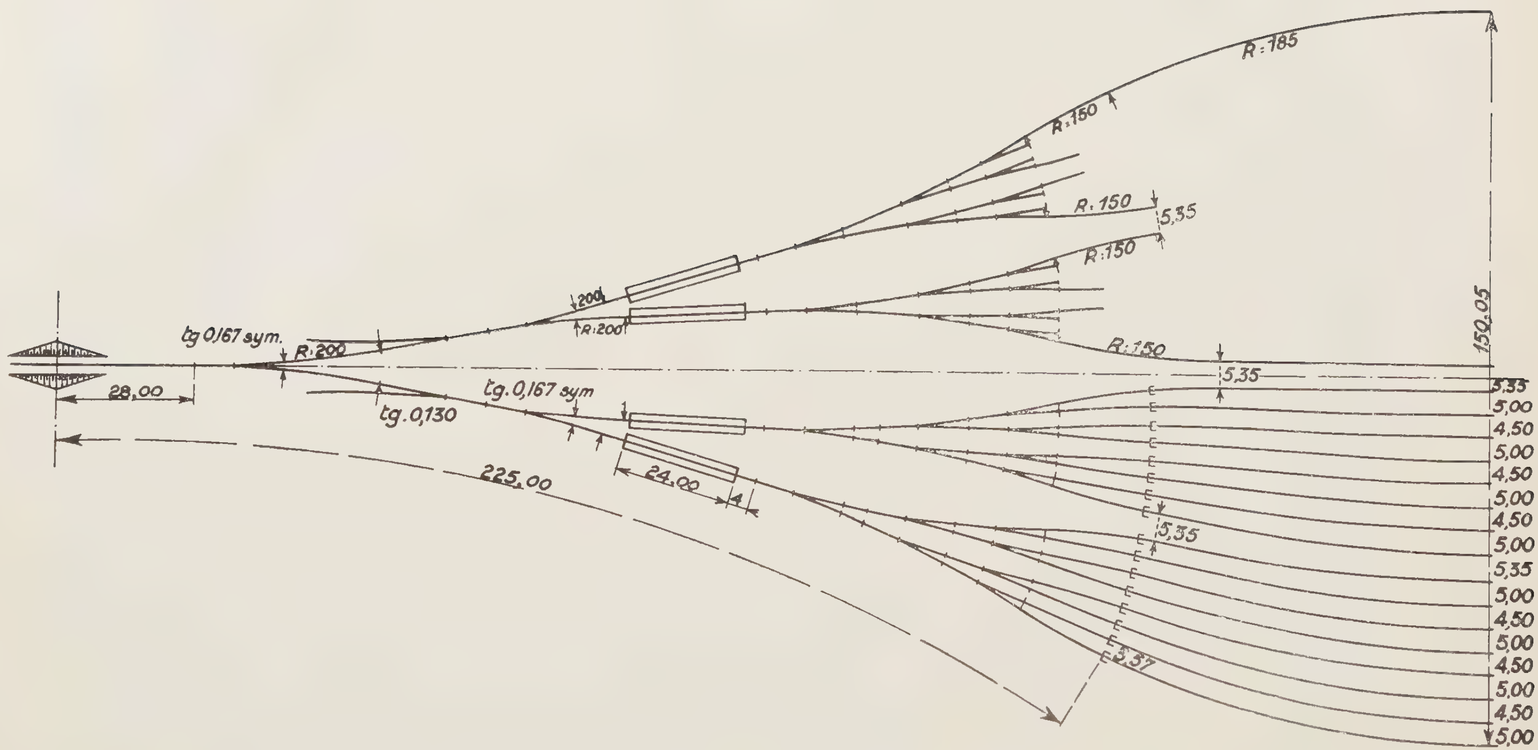


Fig. 21. — Lead in to marshalling yard with 32 sidings and one hump siding (to the scale of 1/1 000).

trains coming in from the opposite direction (or being dispatched in the opposite direction) so that loops or connecting lines will have to be made;

c) With the exception of track brakes which are unfortunately too costly to be used on all the lines of a marshalling yard, the only means available to regulate the speed of the wagons or rakes and to stop them is to have employees on them to apply the hand brakes or to brake them at frequent intervals by hand operated skids.

In both cases, this involves using many men and the resulting costs would appear to exceed the economies to be expected from the saving in shunting engines.

With the exception of a very limited installation on a continuous gradient at from the point of view of staff costs, as it is possible to hold rakes stationary and to regulate their speed during shunting either by means of screw brakes on the rakes or, preferably, by track brakes fitted at the end of each of the reception tracks.

France points out however that the cost of making an automotive incline is considerable in the case of marshalling yards on level ground, and increases in proportion to the number of reception tracks.

On the other hand, in order to assure that the rakes will move on under all circumstances, it is essential to have a very accurate profile for the automotive incline, which sometimes leads to difficulties when the embankment is made on marshy ground; it was partly due to these draw-

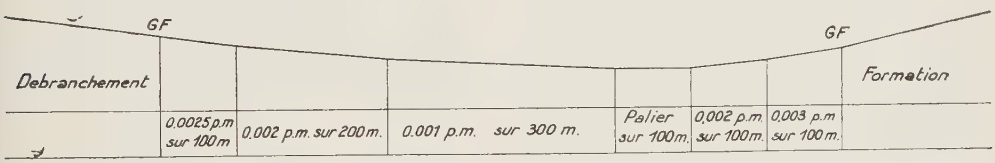


Fig. 22. — Profile of the main marshalling group of sidings.
Débranchement = Shunting. Formation = Making up. Palier sur 100 m = Level over 100 m.

the making up sidings of Bale marshalling station (Switzerland), only Italy has such a yard at Novi with a daily capacity of 1 500 wagons, on a continuous gradient of 11 mm per m (11 $^0/_{00}$).

All the Administrations appear to be agreed that the construction of an up-to-date marshalling yard on a continuous gradient is out of the question (unless topographical conditions lend themselves thereto) unless braking technique can be improved to making the slowing down and stopping of wagons on continuous gradients economically possible.

11) *Automotive inclines.*

The application of the principle of a continuous gradient to the reception sidings only by making what is generally known as an automotive incline involves fewer drawbacks from the point of view of difficulties of construction and above all backs that France has turned the automotive inclines of several marshalling yards into ordinary reception sidings with shunting humps.

Finally, the progress made in the construction of shunting engines, especially the use in non-electrified marshalling yards of low consumption diesel engines, as well as the generalisation of the practice of having only one man on the shunting engines, naturally reduce the interest of automotive inclines.

To sum up, it would appear that the use of automotive inclines is only worth considering when the site naturally has a suitable profile or when the number of reception tracks is small.

12) *Profile of the groups of sidings and shunting lines in marshalling yards worked by shunting engines.*

a) *Longitudinal sections.*

It goes without saying that generally speaking the tracks of marshalling yards in which the work is done by shunting engines must be more or less on the level so that wagons and rakes can stand on them without any special precautions having to be taken to prevent them moving.

The reception, leaving and connecting yards should preferably be on the level with maximum gradients of 3 mm per m (3 $^0/_{00}$).

As for the main shunting yard, all the Administrations concerned are unanimous in choosing a boat shaped section (Fig. 22), suitable gradients being arranged at the two ends to facilitate the running of wagons set in motion by the humps or restarting them after braking, to help them buffering up on the lines; these gradients however should not exceed 2.5 to 3 mm per m (2.5 to 3 $^0/_{00}$), as beyond this easily running wagons might get up too much speed and become dangerous to the wagons that have already been shunted.

In Italy the maximum gradients of the main shunting yard do not exceed 1.5 mm per m (1.5 $^0/_{00}$), a very low figure which appears to be justified by the climatic conditions in this country;

b) *Cross sections.*

Generally speaking, all the tracks of each of the shunting yards are on the same level, and none of the Administrations concerned has found it necessary to make cambered sections to facilitate drainage.

However in certain marshalling yards, the level of the outer tracks of the main shunting yard has been lowered in comparison with the level of the central tracks to compensate for the resistance of the curves run through by the wagons directed onto these tracks;

c) *Levels of the reception yards and shunting dead end.*

The level of the reception yard in relation to the shunting hump may vary between the two extreme figures, viz :

— a higher level due to the necessity to have a minimum counter-gradient in front of the hump, to compress the springs of the buffers of the leading vehicles of the rakes being shunted and facilitate undoing the fastenings;

— a lower limit due on the one hand to the maximum push power exerted by the shunting engines used, and on the other by the average load of the rakes to be set back; the idea of maximum difference of level between the reception sidings and the hump which formerly was not considered to be of any practical value, must now be taken into account owing to the increase in the train loads or more exactly their linear load, and this consideration is of particular importance in the case of marshalling yards which have to shunt heavy mineral or coal trains.

For example a locomotive able to exert a thrust of 12 t can push a 1 500 t rake to a height of the order of :

— 3.70 m when the rake consists of 20 t 4-wheeled wagons;

— 2 m when the rake consists of 30 t 4-wheeled wagons;

— 1.60 m when the rake consists of 40 t 4-wheeled wagons.

Given these relative levels, it is certainly desirable, so long as this does not lead to difficulties in the reception of the trains, to approximate as closely as possible to the upper limit in order to reduce the work required of the shunting engines and consequently the power costs, and to make it possible perhaps to use less powerful engines. When embankments have to be made for this purpose, the advantages expected and the additional cost must be balanced against each other, as these costs will increase in proportion to the number of tracks in the reception sidings, so that the value and financial returns from the building of the embankment are the less as the number of tracks in the reception yard is higher.

As regards the level of the dead end

shunting and making up lines, similar considerations apply, as far as such operations can concern heavily loaded rakes, which is rather exceptional.

The arrangements to be recommended differ moreover according to the equipment of the hump; when the making up hump does not include a by-pass, the rakes to be made up have to be taken into the dead end line over the hump, and it is logical in this case to raise the level of the shunting dead end as far as possible; the cost of building an embankment is moreover relatively little as only the shunting dead end lines are concerned.

On the other hand when the hump includes a by-pass, the making up operations consist in shunting the rakes from the sidings to the shunting dead end, then from the dead end up to the top of the hump; in this case it appears advisable to make the level of the shunting line half way between that of the yard and the top of the hump.

13), 15) *Section of the lead in to the shunting and making up groups of sidings.*

The capacity and output of marshalling yards depend to a large extent on the output of the shunting and making up areas, which constitute its vital part. The structure and equipment of these areas must therefore be studied in order that the gravity shunting carried out there can take place regularly at a fast rhythm.

The determination of the height of the humps and the sections is a fundamental factor of these studies, and without going into details of the theory of dynamics of the wagons set in motion by gravity, the principles of which are well known, we will merely recall certain essential data :

a) wagons left to themselves, after running over the hump, under all circumstances (cold weather or head wind) must be travelling fast enough to reach their destination line and catch up with the wagons already shunted in order to avoid any further « pushing up » in the shunting sidings.

This condition requires the « *average gradient* » of the lead in to the yard calculated between the summit of the hump and the proper crossing of the destination track to be at least equal to the maximum coefficient of resistance to running of the wagons which can normally be counted upon, this coefficient of resistance varying moreover from yard to yard, according to the climate and siting of the lead in tracks compared with the prevailing winds;

b) the *average gradient* of a lead in being fixed, it is possible to deduce the height of the fall (difference in level between the hump and the proper crossing of the group of sidings) in terms of the length of the lead in. But as this height of fall is too great for smooth running wagons, their excess energy must be absorbed by means of brakes.

The value of having short lead ins to the tracks can again be stressed here, since it makes it possible with a given maximum *average gradient* to reduce the height of the fall and consequently make use of less powerful brakes;

c) the section of the lead in tracks should be « hollowed out » or in other words steep slopes on leaving the hump in order to make the wagons run faster; this makes it possible :

— on the one hand, to increase the spacing of the wagons and consequently facilitate the working of the points and crossings between wagons;
— on the other hand to reduce the risk of wagons catching each other up, the gap in the time taken by smooth running and poor running wagons decreasing with the average speed of running of the wagons.

This very diagrammatic report shows that the characteristics of the average gradient, height of the drop and power of the brakes are closely interconnected, and it is owing to the use of very powerful track brakes that it has been possible to make shunting humps with a satisfactory *average gradient*.

On the other hand, in yards only equipped with skid brakes, which are relatively less effective, it is necessary to limit the height of the hump and consequently put up with the resulting drawbacks : shorter run for the wagons, slower shunting rhythm, etc.

For this reason we will examine separately from the point of view of the section, the lead in tracks fitted with track brakes and those where only skid brakes are used.

Lead in tracks with track brakes.

Owing to the high cost of track brakes, the Administrations concerned have only used them up to the present in shunting areas; the only exception is the Bale (Switzerland) yard where the lead in to the making up area is fitted with two track brakes.

An examination of the plans of the various yards concerned (24 in all) shows that the constructional characteristics are very similar (Fig. 23). The average gradient of the lead in track varies according to the case between

$\frac{12}{1\,000}$ and $\frac{18}{1\,000}$.

As for the section, this includes in general :

— a steep starting gradient varying between $\frac{45}{1\,000}$ and $\frac{60}{1\,000}$;

— an intermediate gradient varying between $\frac{7}{1\,000}$ and $\frac{15}{1\,000}$, at the end of which are sited the track brakes;

— a semi-level section between the track brakes and the proper crossings varying between 0 and $\frac{5}{1\,000}$.

These arrangements in conjunction with appropriate devices to enable the points and crossings to be operated quickly (see Heading V) makes it possible to achieve a high shunting rhythm, in practice of the order of 6 to 8 wagons a minute.

As regards the profile of the part of the lead in track situated below the brakes, we should in order to reply to point 15 of the questionnaire, define the view of the Administrations :

In theory it is better to have 1 level section for some hundred yards after the proper crossings; the brakesman in this way is obliged to let the wagons attain an appreciable speed on passing the brake and the risk of wagons catching each other up below the brakes is in consequence reduced.

This arrangement is systematically used in Italy and Switzerland.

On the other hand Holland states that they provide a slope of $\frac{5}{1.000}$ to compensate the resistance due to the curves of the switches.

As for France, all the possible solutions have been tried : level, gradient of $\frac{2.5}{1.000}$ gradient of $\frac{5}{1\,000}$.

The different experiments carried out by the S. N. C. F. have proved that when a slight gradient is provided, there is no fear of a wagon stopping or running too slowly near the switches owing to unsuitable braking. But the Operating Department considers that on the whole it is better to have a level section, with the reserve that carefully chosen, well trained brakesmen are available.

Lead in tracks without track brakes.

In lead ins where the braking is assured by means of skids, the « average gradients » lie between $\frac{10}{1\,000}$ and $\frac{12}{1\,000}$ and the profile generally includes a starting gradient of about $\frac{30}{1\,000}$ to $\frac{40}{1\,000}$ followed by more gradual gradients : $\frac{5}{1\,000}$ to $\frac{10}{1\,000}$.

These profiles (Fig. 23) are easier than in the case of yards with track brakes, because the skids have a low braking capacity; the reduction in speed which they can bring about is only appreciable in the case of low speeds therefore.

These arrangements are suitable for lead ins to marshalling sidings where the gravity shunting operations are real shunting operations; this is so in particular in the case of yards where simultaneous marshalling is practiced, the starting gradients being reduced to $\frac{30}{1\,000}$ to enable the complete rakes to run up to the counter-hump without using the by-pass.

But in making up areas where the marshalling does not involve long wagon runs (individual making up of rakes by shunting the different lots to the end of the line) or where large sections are dealt with whose average running coefficient is never as poor as that of a single wagon (rectification of the composition of through or semi-through trains) the *average gradient* of the lead in track can be reduced to $\frac{10}{1\,000}$ or even less, according to the direction and climatic conditions.

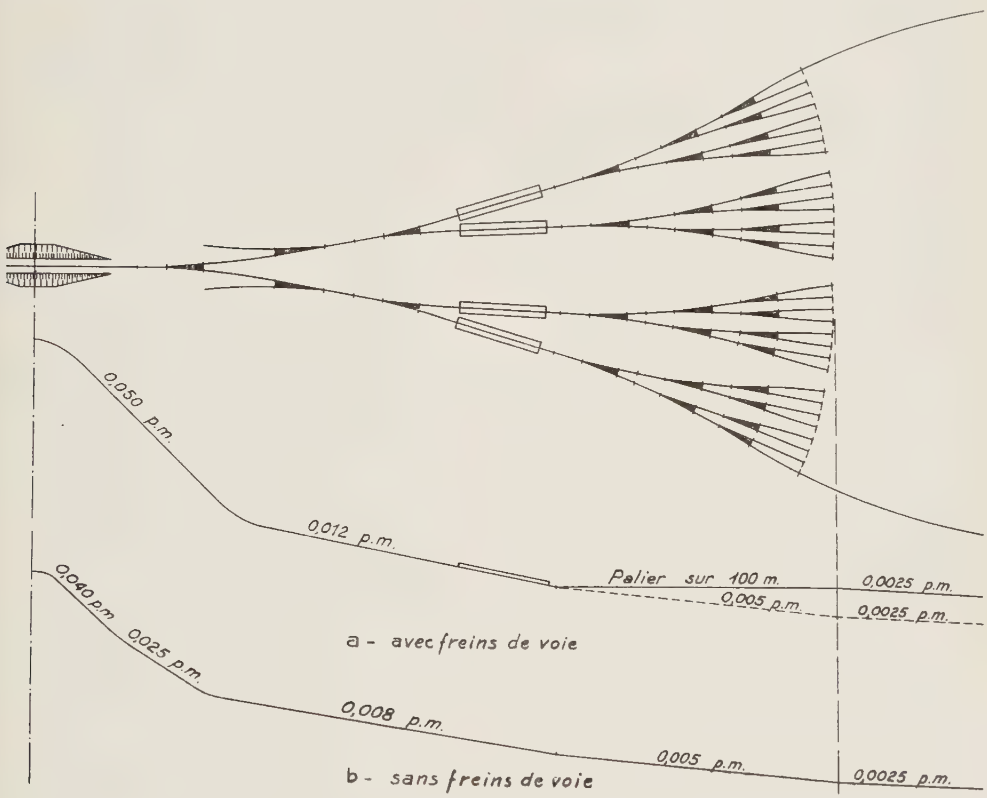


Fig. 23. — Profile of the lead ins : *a*) with track brakes; *b*) without track brakes.

To conclude the examination of the questions asked about the profile, we might add that no Administration has found it necessary to modify the height of the hump according to the season of the year, whether

for shunting humps, which are generally equipped with track brakes, or for making-up humps; whereas, on the other hand, Holland reports that in the near future all their goods wagons will be fitted with roller bearing boxes; the considerations relative to the establishment of the optimum profile will therefore lose much of its value for the Netherlands Railways, the difference in the running of different wagons becoming much less marked as a result.

On the other hand it must be pointed out that dealing with Dutch wagons in the marshalling yards of other railways will lead to an increase in the different times taken by smooth and poor running wagons, which will certainly have its drawbacks.

14) *Limits of the gradients and radii of the transitions in profile.*

To enable the lead in tracks to be constructed with the optimum profile, the Departments in charge of the designs must be subjected to as few restrictions as possible, as regards the study of the profile.

In this connection it may be recalled that on leaving the humps, steep gradients reduce the risk of smooth and poor rolling wagons catching each other up; in addition the radius of curvature of the hump (convex curves) should be as small as possible so that the wagons can reach the steep starting gradient after a short run.

Finally, changes of profile in the lead ins to sidings should be sited on the inside of the turnouts, i.e. between the rigid and undeformable parts of the points and crossing: for this purpose, the transition curves in profile (concave curves) should be small and consequently of small radius.

However, the constructional conditions of locomotives, especially the suspension of the wheels, makes it necessary to limit the radius of the curves in profile in order to obviate risk of derailment, and the restrictions imposed in France and Switzerland are stricter for train engines than for shunting engines.

On the other hand, the minimum radius of the convex transitions should be determined in such a way as to permit of the normal passage of bogie wagons and long low loaders.

Finally, as regards the maximum gradients, it is necessary to take into account the variations in the water level in the boilers of steam locomotives, to prevent the top of the firebox being uncovered on steep gradients.

Table 2 sums up the replies from the Administrations concerning the limiting conditions imposed in this connection in the construction of their installations.

***

IV. — THE BRAKES.

Most of the Administrations concerned do not make use of distance operated skids to brake the wagons wholly or in part.

Only France has certain installations :

- either to equip certain large marshalling yards built before track brakes were invented;
- or more recently to equip average sized yards, the capacity and output of which do not justify the large capital investment involved with track brakes.

The French equipment is of well known types [1], i.e. :

- the Deloison brake : skid operated by means of a cable transmission with electric motor : the braking may be over 30 m (98′ 5 1/8″), but only the leading pair of wheels of the rake is braked;
- the Farenc brake : skid placed on the rail by an electric motor and restored to its initial position by a powerful spring. The braking path is short : about 6 m (19′ 8 1/4″), but the skid can operate on several pairs of wheels of the same rake in turn, about one in three.

[1] See the Report by Messrs PELLARIN and FARENC in the December 1929, *Congress Bulletin*.

The working of this equipment is satisfactory, but their maintenance is difficult and rather costly; it would appear that in the present state of knowledge and taking into account the constant increase in wagon loads, braking mechanism based on skids is insufficiently powerful and too fragile if they are to be used other than as temporary or supplementary equipment.

We think therefore the fact should be stressed that the problem of braking in the secondary marshalling yards as well as in the making up areas of large yards is not yet solved; in general the braking is assured by means of hand operated skids, and it would be a good thing to draw the attention of designers to the great value track brakes of a lower power that were economical both as regards first cost and maintenance would have in the case of such yards.

However in the following pages we will only deal with power track brakes; as these are the only ones used in the shunting areas of the large modern marshalling yards of the Administrations who replied to the questionnaire.

16) *Site and function of track brakes.*

In all installations equipped with these brakes they are sited about the middle of the lead in to the sidings on the common sections giving access to the 8 to 10 track groups.

In principle therefore there are 4 brakes for the lead in tracks when there are 30 tracks, which is the most usual case.

These brakes must be sufficiently powerful to stop the wagons if needs be before they leave the installation, and their normal function is :

— on the one hand *to bring to a stop,* i.e. let the wagons being shunted run at a speed just sufficient to reach the wagons already standing on the track they are going to;

— on the other hand to assure the *space braking,* i.e. regulate the speed of the wagons to prevent any danger of them catching up with each other near the switches below the brake.

This risk is not very great and can only occur if two successive wagons are intended one for a full track and the other for an adjoining empty track; the object of limiting the number of tracks with track brakes and making them extremely short is to reduce this work to an acceptable rate, compatible with the high speed at which the shunting operations are being carried out.

An installation of this type is sometimes completed by a *hump brake* sited at the foot of the hump which can be used to cover various functions.

The hump brake can be used to space the wagons on the section between the hump and the main brakes if, taking into account the rhythm at which the shunting is to be carried out and the characteristics of the installation, it is feared that the wagons will catch up with each other before they reach the main brakes.

In this case it is necessary to slow down the wagons which are *thought* to be free running (loaded flat wagons for example) which follow immediately after wagons *thought* to be poor running (empty covered wagons for example), but it is obvious that the efficacity of this spaced braking depends to a large extent on the judgment of the brakesman.

The hump brake can also be used systematically in the summer to brake all wagons without distinction in order to absorb part of the excess speed given them by the hump; this idea will make it possible to reduce the power and consequently the length and cost of the main line.

In fact, out of the 29 large marshalling yards, plans of which were sent to us, only 5 French yards were equipped with hump brakes.

17) *Number of brakesmen and site of the control boxes.*

When track brakes first made their appearance in Europe, it was considered

that the brakesman could only operate two track brakes and it was necessary to provide two men for the classical arrangement of 4 brakes on the main line.

This idea is still adhered to in Holland in new marshalling yards; at the present time they have no shunting yards equipped with 4 track brakes, but they consider that with such equipment the control box should be sited in the centre of the yard, so that each brakesman can have an uninterrupted view of the two brakes in his charge (Fig. 24).

On the other hand, in France, Italy and Switzerland, it is now thought that the 4 brakes can be operated by a single man whose box is then sited at the side of the yard so that he can see all the equipment (Fig. 25); experience has proved that a single brakesman will not have any difficulty due to the distance at which some of the brakes are from him, and he can carry out all the braking operations necessary for a working speed of 6 to 8 wagons a minute. Everything possible is done to facilitate his work, especially to make sure that he is kept informed of the destination of the wagons being shunted.

As regards the hump brake, the man in charge of this generally has a small hut beside it, the hut being raised up in most cases so that he sees what is in the wagons, opens and flats.

18) and 19) *Supplementary hand braking.*

The efficacity of the track brakes depends to a large extent upon the skill of the brakesman, who has to judge the distance the wagon has to run, i.e. take into account the occupation of the tracks, so that he stops braking the wagons as soon as he thinks their speed has been sufficiently reduced.

Mistakes can be made and the resulting consequences differ according to whether there is too much or too little braking.

In the first case the wagon stops too soon, and a shunting engine has to be used to make up for the mistake; in the second case the wagon will crash into the stationary wagons, and this may result in too severe a shock which will damage the stock and especially the goods being carried.

From the commercial point of view only, it is essential to avoid any shocks likely to damage the goods being carried, and all the Administrations consider that for this reason it is necessary to have supplementary braking, carried out by means of skids operated by men distributed over the lines of the shunting yards.

Generally, the skids are kept on the rail until the wagon is brought to a standstill, and no device is provided to remove them; the brakesmen take advantage of the slipping back of the wagon when it stops to remove the skid.

The facts outlined above show the difficulties of the brakemen's task.

The proper working of a marshalling yard from the point of view of its output and correct user of the lines with the minimum of shunting and damage depends to a large extent on their skill. It is necessary to select and train the brakesmen, but it is also necessary to facilitate their work by making it possible for them to decide with some degree of certainty the speed required for each wagon after braking.

If the braking can be more regularly carried out by the brakesman so that the wagons always come right up against the preceeding wagons but sufficiently slowly to make sure there is no danger, the quality of the service can be improved whilst at the same time reducing the number of brakesmen required to keep up with the work.

For this reason it would be desirable to have equipment making it possible, as defined under question 22, to determine the amount of braking required by each wagon in terms of its rolling characteristics, speed, and route.

None of the Administrations have any such equipment; only France is interested in this problem; after having invented an automatic installation, based on mechanised skid brakes (apparatus R) which was destroyed and has not been repaired, she has

undertaken the preliminary studies in connection with yards equipped with hand brakes, but nothing has yet been put into use.

20) and 21) *Characteristics of the track brakes used.*

The track brakes used are of three types :

Froelich (France, Italy, Holland and Switzerland) : 10 installations in service; modifications of design intended to improve its regulation and working, especially when very different widths of tyres are in use.

The Froelich and Saxby brakes are based on the same principle : the drive is hydraulic and the braking can be applied gradually; at its limit, the braking action is proportional to the weight of the wagon.

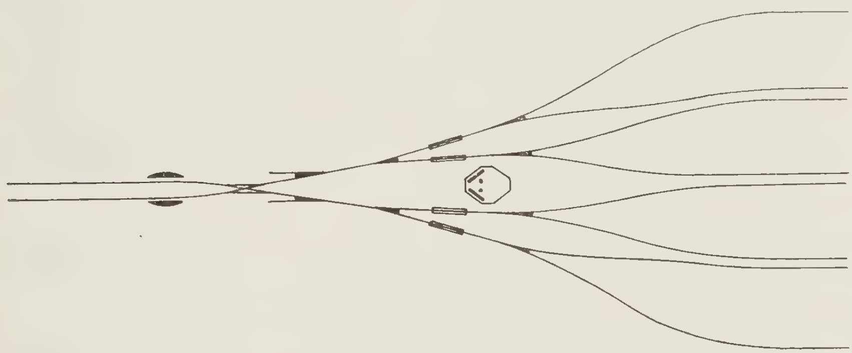


Fig. 24. — Brake post inside the lead in.

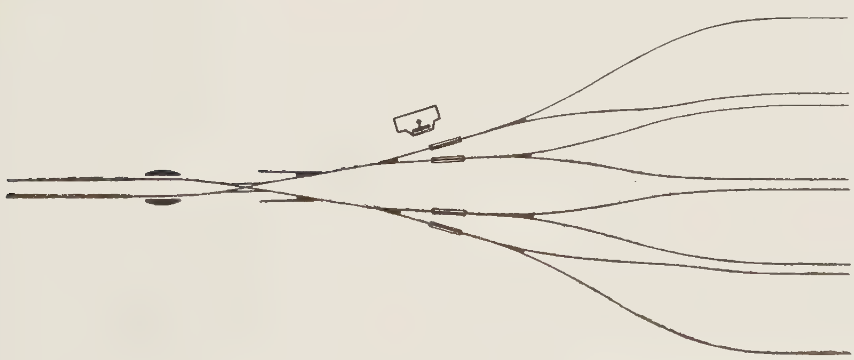


Fig. 25. — Brake post at the edge of the lead in.

Saxby (France) : 1 installation in service;

Westinghouse (France) : 11 installations in service.

A diagrammatic description of these different types of brakes is given in Appendices 4, 5 and 6; in particular we thought it of interest to give details of the Froelich brake although this was in use before 1930, as since that date it has undergone certain

On the other hand the Westinghouse brake is an electro-pneumatic brake and acts independently of the weight of the wagons; for this reason its structure is relatively simpler and it does not take so long to put it in place or replace it, merely a few hours, which is a considerable advantage for the Operating Department; however the consumption of power is definitely

higher. Experience of the Westinghouse brake has proved that it is possible, without serious inconvenience, to make use of brakes which are independent of the weight of the wagons as though sometimes wagons may lift slightly owing to an excess of braking, no derailments have been recorded.

Finally, only Westinghouse brakes can be divided up into two or more sections electrically insulated; to enable the installation of short lengths of insulated rails such as are required for example with automatic shunting (see Heading V); but up to the present it has not been found necessary to make use of this property.

All these types of brakes react to their control within a very short time, about 1 or 2 seconds, which has never led to any criticisms.

Cold has no effect on the braking effect of these brakes; but France reports that in spite of the use of anti-freeze products the hydraulic pipes of the Froelich and Saxby brakes have to be heated if they are not below ground as soon as the temperature falls below — 5° C.

As regards the braking power, this is generally independent of the thickness of the tyres braked, as far as the standard stock of the European Administrations is

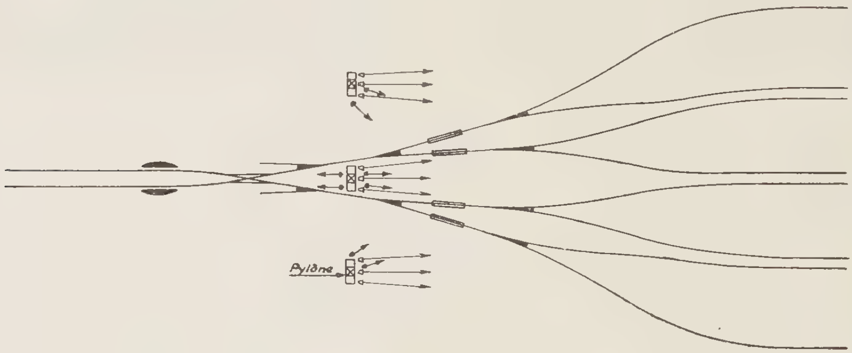


Fig. 26. — Lighting by projectors at the end of the yard.

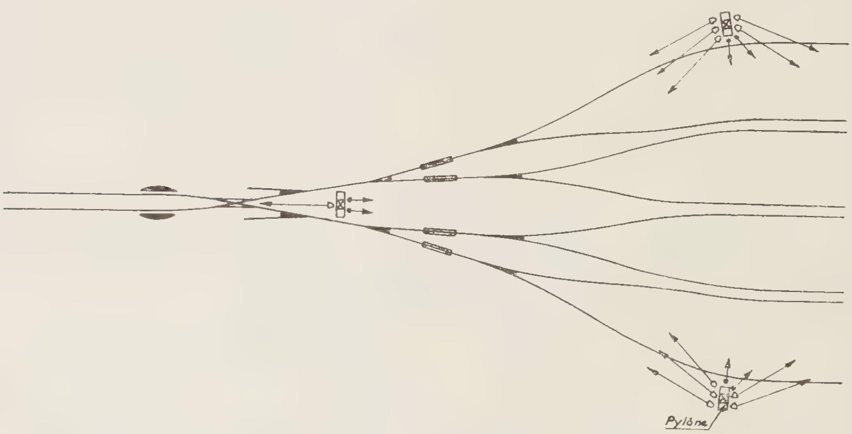


Fig. 27. — Lighting by projectors at the edge of the yard.

concerned at any rate; Italy reports however anomalies in the braking for tyres with a thickness of between 130 and 135 mm (5 1/8″ and 5 21/64″); France has experienced certain difficulties, which have however been remedied, but solely in the case of wagons fitted with narrow 126 mm (4 61/64″) tyres made in England which do not meet the standards of the R. I. V.

The effectiveness of the brakes is diminished either by wet weather, or owing to the presence of lubricants on the wagon wheels : paint, grease, etc.

The normal braking power [1], translated into height of drop absorbed by metre of brake, is of the order of :

— Froelich brakes	0.17
— Saxby-Marchais brakes	0.22
— Westinghouse brakes :	
4 wheeled wagons weighing 30 t in all	0.19
4 wheeled wagons weighing 40 t in all	0.14
8 wheeled wagons weighing 70 t in all	0.11

This shows that though the power of the Westinghouse brakes is about the same as that of the other brakes in the case of ordinary wagons, it becomes appreciably less in the case of very heavy wagons, which are however exceptional; for this reason the length of the brakes used is generally greater : 23 m (75′ 5 1/4″) for the Westinghouse brake with two parts which can be worked separately, compared with 14 to 17 m (45′ 11″ to 55′ 9 1/4″) for the Froelich and Saxby-Marchais brakes.

The length of the Westinghouse brake gives the brakesman greater latitude in regulating the speed of the wagon in the brakes, but on the other hand involves extending the shunting lead in.

23) *Expenses relative to the installation of the brakes.*

The replies received are summed up in Table 3; we will not make any comment upon them, owing to the important differences as regards evaluation, which must be due to a large extent to different standards in determining the cost price.

***

V. — CENTRALISED CONTROL OF THE MARSHALLING POINTS AND CROSSINGS.

In large marshalling yards the conditions under which the points and crossings are worked differ according to the kind of siding groups.

The points at certain lead in tracks may be worked at site, either because the movements are few in number and would not justify the construction of a box (lead ins to the connecting tracks, or departure tracks), or because the men already working there can without inconvenience be charged with working the switches; for example in the case of points and crossings on the hump side of the lead in to the reception sidings.

But in other cases the points and crossings are generally working from mechanical, electrical or pneumatic boxes.

We will deal specially here with the centralised control of the points and crossings by motors.

The *motorisation* of the points and crossings has a great many advantages; it makes it possible to extend the sphere of action of the boxes, and above all to speed up the work because it does away with all physical effort in working the levers and the pointsman does not have to do much moving about as all the control buttons owing to their small size can be grouped together on small panels.

The motorisation of the points and cros-

[1] It should be noted that the braking power of track brakes depends upon the height at which the jaws fasten upon the wheels and consequently upon the construction gauge of the underparts of the rolling stock; the U. I. C. should undertake an investigation into this subject in order to raise this gauge in the case of future wagons, but its efforts will only bear fruit in the distant future.

sings is of the greatest interest as far as the shunting zone is concerned, and has been almost systematically applied; the arrangements made for the construction in plan and section of the shunt lead ins in order to improve the conditions under which the wagons circulate and consequently the output would not have amounted to much if at the same time some way had not been found to facilitate and speed up the work of the pointsmen who, when mechanised boxes are used, can not normally work at a greater speed than 3 or 4 wagons a minute.

24) a) *Characteristics of working the points and crossings by motor in shunting yards.*

The motors working the points and crossings of the shunting yard should work very fast; it is essential that the time taken to reverse the switch be practically instantaneous, so that the pointsmen can without hesitation order a switch to be reversed even when a wagon being shunted has practically arrived at it.

For this purpose all the Administrations make use of electric point motors which take between half a second and a second to act.

As the shunting yards frequently have to deal with various types of movements: putting engines at the head of trains, train departures, shunting to withdraw wagons, shunting into marshalling sidings, etc., it is desirable that the points can be run over in both directions, even when they are not in position, and, when this is the case, running through them in the reverse direction automatically reverses them.

Motors meeting these conditions are known as *reversible;* their use prevents:

— on the one hand damage to the motors when a switch is run through in the wrong direction;
— on the other hand, the risk of trains or shunted rakes becoming derailed when in reversing they run back on a switch that they have just run through in the wrong direction.

Finally, provided steps are taken to meet any possible failure of the electric supply (batteries or standby sets) it is necessary, in order to avoid having the whole marshalling yard put out of action should any breakdown in the supply occur, to fit hand operated levers at the points; these levers can be:

— either dependent upon the motor and rapidly put into work through the meshing of a clutch lever (the most convenient solution for the Operating Department, but the most expensive);
— or independent of the motor and put into use by the maintenance staff after the motors have been uncoupled.

24) b) *Insulated rails at points and crossings.*

When it is considered necessary to prevent the switches being worked prematurely when a wagon is passing over them, pedals and more generally insulated rails are used, the occupation of which cuts off the points motor electrically.

Insulated rails must start well before the points of the switches, the length being such that the wagons can never reach the point of a switch the direction of which, operated at the last minute, is not yet completed.

In addition the length of the insulated rails, which it is desirable to reduce to the minimum, making if needs be insulation breaks in the track equipment, must be at least equal to the wheelbase of the longest wagons, i.e. 12.50 m (41′ 3/16″) in practice for the current rolling stock of the European Railways.

The result is that in order to work a switch between two wagons, the spacing of the wagons must be more than 12.50 m, and this minimum space generally makes it possible to eliminate all risk of the wagons catching each other up before reaching their proper turn out.

However, when the minimum space of 12.50 m required for the use of insulated rails is considered unacceptable, it is possible to get over this drawback by the

use of photo-electric cells. In up-to-date French marshalling yards, the first shunting switch is always fitted with a photo-electric cell.

The insulated rails or similar devices (pedals, cells) do not merely prevent derailments owing to the switches being worked prematurely; they also considerably facilitate the work of the pointsman, as they make it possible for him, when two successive wagons are running towards the switch, to prepare the movement of the switch for the second wagon before it has been cleared by the first wagon.

The movement is blocked by the occupation of the insulated rail, but will take place as soon as it becomes unoccupied, which in practice gives a sort of pre-selective operation of the switch.

However, it has been found that whatever improvements may be made to the installations for working the switches, the shunting output is limited to a certain ceiling, which corresponds to the practical speed at which the pointsman can continue to work under the special conditions in which he finds himself, which require him to keep a check simultaneously on the running of several wagons and to work the switches at the right moment, keeping in mind all the time the different destinations to which the different wagons are to be sent.

In this connection, experience has proved that in a shunting yard where all the switches are motorised but worked individually, a pointsman in practice cannot exceed an output of more than 5 or 6 wagons a minute.

25) *Automatic control of the shunting switches.*

To obtain a higher output, it becomes necessary to reduce the time the pointsman takes to react and consequently arrange for the *automatic control* of the shunting switches when the control will no longer be carried out individually by switches but by routes.

In general such control affects each wagon as soon as it gets over the hump, and the working of the switches then takes place automatically at the proper time, the running of the wagons being controlled by means of insulated rails or other similar devices.

In addition individual control handles for each automatic switch are provided for the use of the staff (pointsman or brakesman) to enable them to :

— intervene for exceptional reasons during shunting, to rectify at the last minute the route of the wagons or to make good any failure of the automatic control;
— or, outside shunting times, to carry out shunts or other movements on the lead in to the sidings.

There would not be much point in describing here the different types of equipment which have been invented to give automatic control of the shunting switches, but on the other hand, we must insist upon certain aspects of their design which may affect operating conditions.

1. — The control of each route is assured the moment the wagons passed over the hump and the routes are *registered* by the equipment and remain registered until the wagons in question have passed the last switch with automatic control on their route.

The automatic control apparatus for shunting switches must therefore be able to register at a given minute the same number of routes as there may be wagons in circulation from the top of the hump to the end of the automatically controlled switches.

2. — Certain Administrations (Italy, Holland, Switzerland) complete this automatic control of the switches by a route *booking* device which makes it possible to prepare in advance the routes for all the lots of a rake to be shunted (generally about 50); the routes are then controlled and registered automatically as soon as each lot passes over the hump.

The use of such booking devices presupposes that the waybills of the trains are always correct and in particular that no change in destination is to be made normally during shunting; on the other hand they appear to be of value for the Operating Department when they make it possible to save a man, i.e. when the operating conditions are such that it is not necessary to have a man at the hump to carry out other duties.

3. — If two successive wagons catch each other up in the automatically controlled switch area, the equipment will work normally for the destination route of the first wagon; but although the route of the second wagon has not been completed, it is desirable that this route be automatically cancelled by the equipment.

When the automatic control of the switches does not do this, it is necessary for an employee to intervene to cancel the route of the second wagon and thus prevent mistakes in the working of the switches for the following wagons (point 26 of the questionnaire).

4. — Extent of the automatic switch control area. Certain Administrations (Italy, Holland, Switzerland) have merely applied automatic control to the first two or three stages of the switches in the shunting yard, and retained manual control for the following switches (the last two or three stages).

They consider that if automatic control is a particularly paying proposition for the switches at the lead in to the yard where more than 80 % of the routes divide up, it is not so in the case of the rear switches, the number of which is much higher; they add that there is no inconvenience from the point of view of the output in keeping a pointsman to operate the last switches by hand, as owing to the much fewer number of shunts which he will be responsible for, this pointsman can follow the highest output of wagons (from 6 to 8 a minute) made possible by the automatic operation of the first switches.

In France on the contrary it is considered better to extend automatic control to all the shunting switches, not in order to obtain a higher output, but to profit by the saving made by doing away with pointsmen altogether. This Administration also points out that in any case automatic control is not very costly as the switches have in any case to be equipped with insulated rails if a high output is to be achieved together with a satisfactory standard of safety; Italy is also preparing to put into service an installation of this type at Bologna.

On theory alone it is difficult to decide between these different solutions, and we think it is for each Administration to draw up a financial balance sheet for the two solutions, taking into account the characteristics and cost of the automatic control equipment used; we wish to stress the fact however that equipment that does not meet the requirements of point 3, i.e. which does not automatically carry out the registered routes of wagons which catch each other up make it necessary by their very principle to retain a pointsman.

27) *Brake and switch posts.*

Generally, the brake and switch posts of new marshalling yards are sited at the lead ins to the yards they control (see paragraph 17 for brake posts).

However certain Administrations site their switch boxes in the centre of the lead in to the tracks, especially when the latter are very extensive, in order to give the pointsmen a better view of the whole of their working area.

Applications of this formula, which is of rather exceptional character, concern :

- Holland : shunting yards when the switches below the brake are worked by a pointsman; this man works in the building provided for the two brakesmen in the centre of the yard near the brakes (Fig. 24);
- France : certain marshalling yards, the corresponding switch posts being scat-

tered, can be occupied by one or two pointsmen as required according to the time of working.

All the Administrations raise up the signal boxes so that the brakesmen and pointsmen can see the whole field of work even when there are wagons on the lines nearest the boxes; they also endeavour to improve the visibility by siting the boxes on the best side of the lead in to the tracks from the point of view of orientation and by making such buildings with large bay windows and sun blinds.

We must also stress :

a) that the lever table or framework should be sited as near the windows as possible;

b) that it is desirable, when an unobstructed wall can be arranged, to have a cantilever roof, without any support on the three glazed sides; in this way there is no obstacle in the brakesman's vision apart from the window-framing;

c) the inside lighting at night must be specially studied, so as not to make it difficult to see what is going on outside; the general inside lighting, during working hours, should in principle be less than the lighting of the yard outside the employee's control.

***

VI. — THE CONNECTIONS.

The equipment of an up to date marshalling yard should include a fool proof system of correspondance and communications making it possible to give instructions rapidly and transmit orders or working papers.

a) *Communication between boxes.*

The basis of this system is the telephone system between the various fixed boxes : offices, signal and brake boxes; this telephone system generally includes a manual or automatic exchange, which is sometimes completed by certain special lines :

— special lines making it possible for the staff in charge of the shunting to get in touch with the different marshalling posts as well as the Office, Maintenance and Staff Departments direct, for example by means of special circuits with selective relays;

— direct lines between signal boxes assuring safety communications by priority.

Some of these lines can be replaced by internal *loud-speakers* when employees have to exchange many messages during their work; this makes it unnecessary for them to use the telephone and hold the receiver in their hands.

The use of internal loud-speakers is general for example in communications between the shunting hump and the brakesman and pointsman as required; it is sometimes also used in the making up area.

Certain Administrations have also installed loud-speakers to give communication between those in charge and the busiest parts of the yard.

b) *Communications between the boxes and the men out in the yard.*

Long distance conversations between the boxes and the men out in the yard are generally carried out by telephone.

When, as is most frequently the case, orders have to be given by the boxes, the staff are called to the telephone by powerful bells or klaxon horns; but when orders have to be given frequently, *outside loud-speakers* are used to prevent any delay in the work.

The outside loud-speakers are considered very satisfactory from the point of view of power and clearness. The only obstacle to their use is the nuisance caused to adjoining premises.

The use of such equipment is more or less general for the transmission of orders from the hump box and brake boxes to the men charged with sending back the wagons, and they are supplemented by the use of the ordinary colour light signals formerly used.

Finally, when much less frequently, the outside staff have to talk to the boxes, they

have to go to a telephone, and so far no need has been found to instal such equipment as the *talk-back speakers* sometimes used in America which include very sensitive microphones recording out in the open words spoken several dozen yards away.

It should also be noted that technical progress made during the war now makes it possible to equip boxes with portable short-wave wireless transmitters (1.90 m) with a radius of action of about one kilometre, which weigh less than 3 kg, including the aerial and batteries; such equipment would appear to be very useful and certain Administrations are interested in it, though the practical application thereof has not yet been achieved.

France, for example, is considering facilitating the work of the markers off which is particularly hard and disagreeable during bad weather, by giving the information about the trains to be shunted by radio-announcement.

The safety of men working amongst the tracks makes it impossible to provide them with earphones and it is necessary for them to have a small loud-speaker, which gives rise to certain difficulties.

c) *Communications between the shunting posts and the shunting engines* [1].

Communication between the men shunting or making up the trains and the drivers of the shunting engines is normally assured by mechanical signals or preferably light signals, which are generally worked by the man in charge of the hump.

These signals order the driver to run back or stop; in recent installations they also give such indications as *speed up* and *slow down* so that the speed at which the rakes are backed can be regulated at all times according to the desired rate of working.

To make it easier for the drivers to see them, the shunting signals are repeated at several points along the shunting lines and the changes of signal are generally accompanied by an acoustic signal (klaxon horn).

When shunting is being done with two engines working in turn, it is often necessary to double the signals.

As regards the aspect of the light signals, coloured lights can be used if these will not confuse the drivers of locomotives on adjacent main lines, or otherwise multiple white lights, the code being based on various combinations of position.

Amongst the Administrations who replied, Italy and France have carried out trials of communication by radio between the hump and the driver. Italy has installed a unilateral installation at Milan, with a wave length of about 2 m.

In France, an installation of the *Telefunken* type with waves guided by aerial circuits set up in the area in which the engines work was put into service at Bourget before the war and is still working.

Since the war, however, radio communication equipment, manufactured in America or France, has been tried out in a dozen marshalling yards: some of them, being unilateral, only enable the chief shunter to give orders from the hump to the engine driver; other more complicated types, being bi-lateral make it possible for them to talk to each other, and in particular enable the drivers to acknowledge the orders received. The latter type of equipment has proved of greater value and usefulness in practice.

The wave lengths used are very short, of the order of 1.80 m; the frequency varies according to type between 159 and 166 MHZ.

The power on the locomotives is supplied by a converter fed by:

- either an accumulator on diesel locomotives;
- a special battery charged by a turbo-dynamo on steam locomotives.

[1] None of the Administrations concerned has found it necessary up to the present to give communication by radio between the control post and drivers of engines carrying out the work and the other duties.

Most of the installations are so designed as to be able to work on several frequencies which are pre-regulated and stabilized by quartz, one frequency being allotted to each part of the yard: shunting, making up, etc.

At each marshalling yard it is necessary to equip a fairly large number of locomotives, at least as far as the aerial and current are concerned, so that an engine so equipped is at all times available in each part of the yard. Finally the radio equipment itself must be quickly replaceable, so as to assure the service working without interruption in case of a breakdown, the damaged equipment being repaired in the shops.

The perfecting of the French equipment cannot yet be said to have reached its final stage, but it appears ready to enter into current use, so long as it is very carefully maintained in order to obtain perfect regularity of working.

With an eye to the future, it would appear desirable for all the Railway Administrations to have wave lengths suitable for use in the marshalling yard services allocated to them.

d) *Methods of handing over the shunting sheets and waybills.*

Only Switzerland makes use of pneumatic tubes to send the shunting sheets from the foreman to the men out in the yard; the other Administrations send all papers by employees; no mention was made of the use of aerial carriers nor of teleprinters.

France stated that in principle cycle tracks 1.75 m (5′ 8 7/8″) wide are arranged alongside the sidings, to enable the staff to carry papers rapidly by bicycle or motor bicycle, as well as light equipment such as the rear lamps for trains; whenever possible, the width of these tracks is increased to 3 m (9′ 10 1/8″) to allow light trucks to be run on them to carry the heavy equipment of the linesmen or rolling stock department, or even the staff themselves.

***

VII. — LIGHTING OF MARSHALLING YARDS.

The work carried out in marshalling yards makes it essential to have good lighting to safeguard the men working among the tracks and to enable the work to be done properly; since up to date marshalling yards are designed to give a high output in the shunting and making up of trains, it is essential that the work can be done as well by night as by day.

30) *Characteristics required of the lighting.*

The needs of the Operating Department vary according to the different yards and even in different parts of the same yard; the lighting required depends in each case upon the frequency and nature of the operations carried out.

For example in the departure sidings, not much light is required, since in practice the only work that has to be done is putting the rakes into position or the engine at their head.

On the other hand in the reception, shunting and making up yards, many employees (markers out, inspectors, couplers, etc.) have to move about and work; although each man has his own lamp to light his work, it is also necessary to have some general lighting, to allow the men to get about and avoid accidents due to the presence of obstacle or the carrying out of the work.

Finally, in the lead ins where work is very active, particularly in the shunting and making up yards, the lighting must be brighter; the wagons being shunted must be visible all the time, so that they can be seen both by the men in the boxes (pointsmen and brakesman whose sphere of action is often fairly extensive), and the men on the site (especially when there are no brakes, by the men who have to operate the skids at the lead ins tracks).

These considerations have led the Administrations to set up lighting standards,

which are approximately the same in every case :

France :

lead ins to yards with brakes.	3 to 6 lux.
lead ins to yards with skid brakes	5 to 8 lux.
yard sidings	1 to 3 lux.

Italy :

lead ins to yards	3 lux.
yard sidings	1 lux.

Holland :

lead ins to yards with a high output	9 lux.
lead ins to yards with an average output	6 lux.
area in which skid brakes are applied	5 lux.
yard sidings	2.4 lux.

Switzerland :

lead ins to yards	5 to 10 lux.
yard sidings	1 lux.

Whatever the amount of lighting considered, the lighting should be uniform and without any risk of direct or indirect dazzle; suitable transitions from one degree of lighting to another must be arranged so that there are no marked contrasts which can be a strain on the eyes.

31) *Types of lighting.*

In respecting the conditions outlined above, the services in charge of the lighting installations must design an economic installation, both as regards first cost and operating costs.

As the light output of lighting equipment increases with their intensity, the constant tendency is to make use of brighter sources of light placed at a greater height.

In Switzerland, the lighting is assured by means of lamps sited throughout the sidings; the lamps of average power are carried on posts 10 or 15 m (32′ 9 3/4″ to 49′ 2 1/2″) high.

The same sort of arrangement has been adopted in Holland, but sodium lighting is used and has been found very satisfactory. The advantages of this method of lighting are well known : higher luminous efficiency (lumen watt) than that of the best filament lamps in spite of a reduced electric power factor, non-dazzle, well diffused, with soft shadows and penetrating well through smoky or foggy atmospheres.

In general, however, the railways hesitate to make use of sodium lighting in marshalling yards for fear that the drivers may find it hard to distinguish the signals, especially the drivers on the adjoining main lines, owing to the yellow colour of this type of light.

In an installation carried out in France at Vaires, the lighting is of the classic type with individual lights, but very powerful lamps have been used : 1 000 to 2 000 watts. The interest of this installation, from the point of view of first cost, lies in the fact that fewer supports are required, and consequently fewer supply lines, owing to the increase in the area lit up by each lamp.

In general however France, Italy and Norway tend to use very bright lights placed at a great height (about 30 m = 98′ 5 1/8″). The pylons carrying the projectors are sited outside the track equipment (flood lighting). The first costs are thereby reduced to the minimum since each pylon can carry several projectors; the lights are localised in principle at the lead ins to the yards and owing to this the electric supply line circuit is particularly simple.

Experience has proved that flood lighting gives very satisfactory results, and though the lights are set at an angle, there is practically no dazzle; the defect of this system is that the central portion of the sidings are poorly lit, either because the lights are too far away (Fig. 26) or because their siting makes it impossible to avoid throwing shadows between the lines (Fig. 27).

The slight drawback is however amply compensated by the lower first costs and above all by the elimination of the all lighting posts inside the yard.

***

VIII. — BUILDINGS AND VARIOUS.

Apart from the braking and switch posts, and their annexes, the following buildings are required in marshalling yards :

a) working buildings : lamp depots, stores and tackles, offices for the foremen, etc.;

b) cloakrooms, lavatories and canteens for the different employees : shuntsmen, markers, brakesmen, inspectors, sectionmen, etc.;

c) administrative offices : offices for the managers, control posts, staff management, etc.;

d) social buildings : medical and hospital services; room for the train staff, etc.

The buildings of categories *a*) and *b*) used by the men of the different parts of the yard are spread over the yard to save useless coming and going, but are grouped together in each part to obtain economical and well designed units.

On the other hand, apart from the rooms for the train staff which are sited in certain cases some way away from the yard so that the men can rest properly, the general tendency is to group categories *c*) and *d*) in a single building known as the main yard building.

Most Administrations site this main building near the shunting yard, making use of the large amount of space available at this point, and also of the fact that so sited, the building is more or less at the centre of gravity of the marshalling yard.

However in France the main building is sited for preference near the making up lead in, especially when the yard is equipped with a departure yard. France considers in fact that the operations carried out in the marshalling yard are always more difficult than those of the shunting yard where the work is more or less routine, so that the direct supervision of those in charge is concerned more particularly with the marshalling yard.

Weighing wagons at the shunting humps.

Although this was not one of the questions raised in the questionnaire, Holland reports that the possibility of weighing wagons at the shunting humps in large marshalling yards is under consideration.

It would certainly be interesting for the Operating Department if wagons could be weighed in this way thus making possible systematically checks of the weight of loads, whilst reducing the number of weigh bridges required at small stations, which are very costly and have a small effective output.

However the perfecting of such equipment and its use is a very delicate matter, as without slowing down the working of shunting the wagons must be weighed with the degree of accuracy imposed by the commercial and administrative regulations.

This is a very difficult problem to solve, which is also under examination in France, and it would be very desirable for the studies undertaken to lead to a successful solution.

Repairs on the spot and rectification of loads.

France also reports having installed in certain up-to-date marshalling yards special equipment to make rapid repairs to wagons and rectify the loads.

Repairs to the stock or rectifications of the loads which cannot be carried out on the track itself with the portable equipment carried by the inspectors, make it necessary to take out the wagons and send them into special shops; in general such wagons are shunted onto a special line and then taken to the Rolling stock repair shop, or into a shed for rectifying the loads; then they are returned to the yard to go on their way.

These successive operations take a lot of time and frequently a repair which only takes an hour or two to carry out delays a wagon for one or two days.

Apart from the operating costs involved, such operations are prejudicial to the turn round and consequently the user of the rolling stock, and they also have the drawback of increasing the transport time in which the wagon is running light.

To overcome these drawbacks, in certain French marshalling yards a special shop for rapid repairs has been installed, sited near one of the side tracks of the marshalling yard; this shop is fitted with lifting tackle so that such work as changing a pair of wheels, as well as replacing loads that have shifted, can be undertaken.

Wagons to be dealt with in this shop are shunted onto the line in question, and

Marshalling

YARDS	Number of wagons coming in during 24 hour period	Number of trains received and shunted in 24 hour period	Total number of trains dispatched after shun[ting] in 24 hour period	
			without geographical formation	with geographic[al] formatio[n]
FRANCE.				
Vaires (pair)	1900	30	35	3
Le Bourget (impair)	2200	43	26	16
Lille-Délivrance	2500	65	50	12
Tergnier	2100	38	31	8
Nantes	2000	43	24	26
Rennes	1500	31	21	11
Trappes	2400	50	42	7
Achères	2500	58	45	10
Juvisy (1)	1800	60	35	35
Toulouse (2)	2500	55	35	19
St-Pierre-des-Corps	2500	57	43	13
Les Aubrais	2300	48	39	7
Villeneuve (2)	4000	80	60	20
St-Germain-au-Mont d'Or (2)	2000	47	42	4
Chasse (1)	1500	53	61	—
Gevrey (2)	3300	55	42	11
Courbessac	1900	40	30	11
ITALY.				
Milan	4000	78	58	25
Bologne	—	—	—	—
Rome	—	—	—	—
NETHERLANDS.				
Watergraafsmeer	—	—	—	—
Susteren	—	—	—	—
SWITZERLAND.				
Bâle	2700	62	10	50
Zurich	2700	82	50	32

(1) Only for parcels and miscellaneous traffic trains.
(2) Yard being built.

when the necessary repairs have been carried out are sent to the marshalling yard; the time spent in the shop is therefore limited to that required for the actual repair operations.

Thus the great majority of wagons requiring repairs or rectification of the load can be dealt with in the yard itself, and loaded wagons hardly ever have to be sent to a Rolling Stock Repair Shop.

Appendix No. 1.

sed since 1929.

ays)	Number of sidings				
nber of trains lispatched 4 hour period the departure up of sidings en provided)	Reception yard	Shunting yard	Marshalling yard	Waiting to leave	Relief sidings
—	10	24	6	—	—
—	10	34		—	5
25	15	32	25	—	—
—	10	32	5	—	8
—	10	32		—	—
—	17	28		—	—
—	14	28	4	—	—
—	11	31	8	—	5
70	5	29		6	—
15	9	40		5	4
35	11	34		6	7
—	12	29		—	11
70	18	44	11	20	—
—	14	35		—	3
—	4	26	—	—	—
20	14	41	6	8	9
—	11	34		—	—
83	22	44	24	35	—
—	20	40	24	18	4
—	14	34	19	12	8
—	10	40		—	—
—	7	14		—	—
60	9	38	14	8	—
55	11	37	19	13	—

Appendix 2.

Constructional details of marshalling sidings.

CHARACTERISTICS		France	Italy	Luxemburg	Norway	Holland	Switzerland
Width of the six foot ways	ordinary	5 m and 4.5 m alternately (4.8 and 4.2 m if needs be)	4 m 50 (4 m on the marshalling sidings)	4 m 50	4 m 50	4 m 50	4 m 50
	with posts	5 m 35	5 m	—	—	5 m	5.00 to 5.20 m
Minimum radius of curves		150 m	150 m	180 m	150 m	140 m	190 m
Special points		tg 0.167	—	—	—	—	—
Distance between the hump and the first switch		28 m	22 to 30 m	70 m	60 m	20 m	31 m
Average gradient of the lead ins	with track brakes	13 to 17 ‰	15 to 17 ‰	—	—	16 to 17 ‰	12 to 14 ‰
	without track brakes	10 to 12 ‰	—	12 ‰	—	13 ‰	—
Maximum gradient of the humps	train engines	35 ‰	50 ‰	35 ‰	25 ‰	66 ‰	60 ‰
	shunting engines	50 ‰	50 ‰	50 ‰		66 ‰	60 ‰
Radius of transitions — convex	train engines	500 m	300 m	300 m	2000 m	—	300 m
	shunting engines	250 m		215 m		—	250 m
Radius of transitions — concave	train engines	800 m	400 m	—	2000 m	—	2000 m
	shunting engines	300 m		—		—	1000 m

Appendix 3.

Cost of installing track brakes (4 brakes).

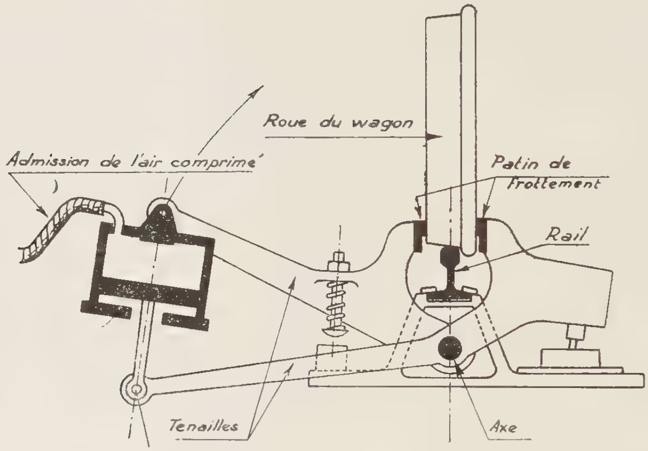
	Froelich brakes				Saxby brakes	Westinghouse brakes
	France	Italy	Holland	Switzerland	France	France
a) Installation costs	»	120 000 000 L (1)	480 000 Fl(1)	»	65 000 000 Fr	65 000 000 Fr
b) Consumption of current . .	213 000 Fr	1 000 000 L	»	»	49 000 Fr	945 000 Fr
c) Maintenance costs	4 705 000 Fr(2)	4 000 000 L	12 000 Fl	»	4 593 000 Fr(2)	5 440 000 Fr(2)
d) Operating costs	4 918 000 Fr	»	»	»	4 642 000 Fr	6 385 000 Fr
$(b + c)$ per wagon shunted . .	= 9.10 Fr	»	»	0.015 Fr. S(1)	= 8.20 Fr	= 9.30 Fr

(1) Exchange rates as at 1/11/1949 :
- Lire (L) = 0.55 Fr. fr.
- Florin (Fl) = 92 Fr. fr.
- Swiss franc (Fr. S) = 82 Fr. fr.

(2) of which more than 3 000 000 Fr. fr. for annual overhaul.

Appendix 4.

WESTINGHOUSE TRACK BRAKE.



Explanation of french terms :

Admission de l'air comprimé = Admission of compressed air. — Roue du wagon = Wagon wheel. — Patin de frottement = Shoe. — Rail = Rail. — Tenailles = Jaws. — Axe = Centre line.

This brake is worked by means of jaw shaped parts, every 2 m (6′ 6 $\frac{3}{4}$″), on each running line.

They tighten up by means of levers one end of which is attached to the piston and the other to the cylinder of a pneumatic motor fed by compressed air by means of a system of valves electrically operated with four adjustments of the pressure corresponding to 4 degrees of tightness braking.

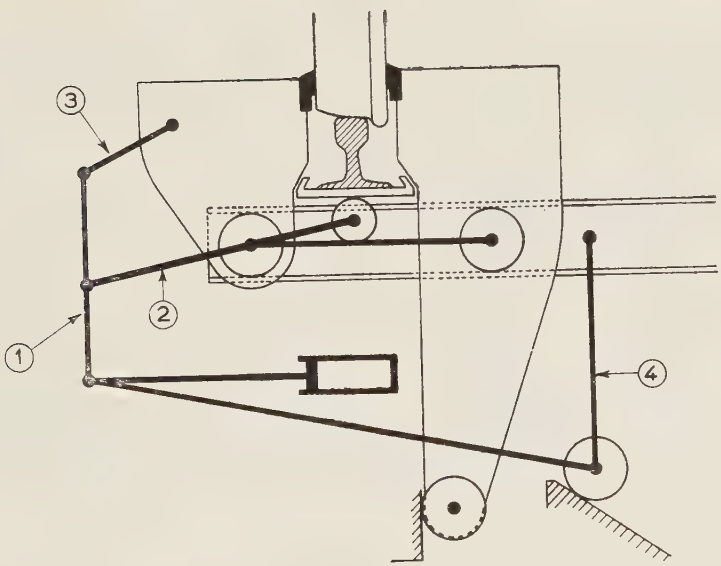
The pressures obtained on each side of the wheel are equal. The brake shoes are automatically centred thanks to the use of levers on each jaw which pivot around their axis of articulation and to coiled springs. This centering prevents lateral stresses being imparted to the vehicles.

The jaws carry the brake beams which are articulated in line with the jaws. On these beams are fixed the braking shoes in such a way that the centre falls in line with the articulation of two consecutive beams. This arrangement ensures the rigidity of the brake as a whole, whilst allowing it a certain amount of flexibility.

The compressed air is supplied by a plant at a pressure of 8 kg/cm^2 (113 lbs per sq. inch.).

Appendix 5.

SAXBY-MARCHAIS TRACK BRAKES.



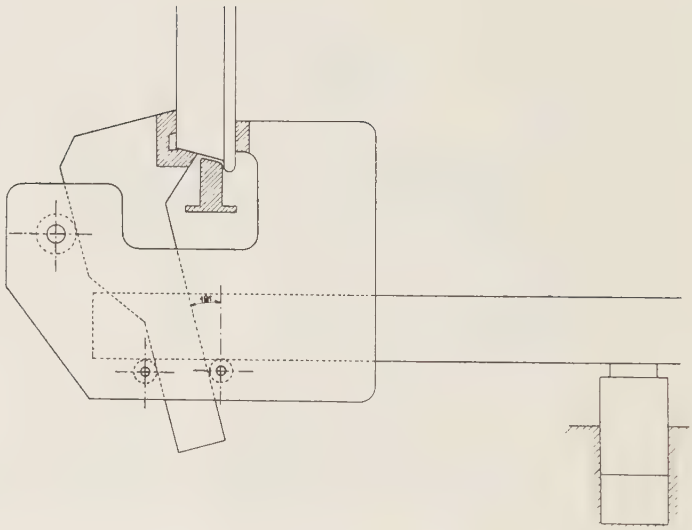
The jaws consist of 2.80 m (9′ 2¼″) elements assembled together in line with the symmetrical levers compared with the centre line of the track.

The brake is put on by the action of hydraulic pressure applied on the piston. The lower end of the equalising bar (1) moves outwards as the whole moving part is lifted by the lever (4). The wheel of the wagon, when running into the flangeway of the brake, opens the jaws. By the action of the rod (3) and the lever (2), the running rail is then lifted up. The weight of the wagon on the rail exercises pressure on the tyre of the wheel in proportion to the weight of the wagon when the hydraulic pressure is sufficiently great to maintain the equalising bar (1) in its extreme position.

If the hydraulic pressure (80 to 110 kg/cm^2 = 1 137 to 1 564 lbs. per sq. inch.) is regulated by the brakesman so that it remains lower than the load of the wagon on the equipment, the braking effort becomes proportional to this pressure which electrical equipment makes it possible to graduate.

Appendix 6.

FROELICH TRACK BRAKE.



The inner jaw is fixed. The outer jaw is mounted on a moveable crutch. The stirrups or straps carrying these jaws are able to move sideways on transversal beams which can be raised or lowered by means of pistons worked hydraulically.

The control apparatus by means of electrical devices enables the pressure in the cylinders to be regulated. The hydraulic power is supplied by means of an accumulator of compressed air (105 atm).

When the hydraulic pressure is great enough to keep the wagon raised above the carrying rail, the total weight of the vehicle rests on the moveable jaws and determines the friction on the tyres of the wheel. The maximum braking effort is exerted at this moment, and is proportional to the weight of the wagon.

[656 .212 .5]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

15th. SESSION (ROME, 1950).

QUESTION VII.

Organizing methods to be used in large marshalling yards and terminals, to reduce to the minimum the cost per wagon shunted.

Determination of the staff and number of shunting engines needed;
Capacity and control of the efficiency of the marshalling yards;
Recording and numbertaking arrangements in the arrival and departure yards;
Statistics and traffic analysis by the control-room;
Braking and retarding arrangements;
The formation of trains for departure.

REPORT

(America (North and South), Burma, China, Egypt, Great Britain and North Ireland, Dominions, Protectorates and Colonies, India, Iran, Iraq, Malay States and Pakistan),

by E. W. Rostern,

Operating Superintendent, Eastern & North Eastern Regions, The Railway Executive, Marylebone Station. London, N.W. 1.

This report is based on information supplied by the following undertakings :

Pennsylvania Rail Road U.S.A.
South African Railways and Harbours
Sudan Railways
Ceylon Government Railways
Government of India Railways
Victorian Railways - Australia
New Zealand Government Railways
British Railways

PART I.

General measures to improve the output of marshalling yards. — Results obtained.

Question 1. — *Do there exist in your marshalling instructions any arrangements which are designed to assist the staff (in particular by indications on wagon labels) in identifying the destination station and the siding into which the wagon requires to be shunted?*

ANSWER.

The usual practice is for all loaded wagons to carry on each side a label indicating, inter-alia, the destination station and the route when this is necessary. In order to help the yard staff, specially printed labels are frequently provided for the larger receiving points which show the destination station in printed letters.

Several undertakings use coloured labels to denote such special traffics as « Perishable », « Fruit », « Explosives » requiring particularly expeditious despatch. A variation of this arrangement is the use on the labels of coloured strips supplemented by a printed description.

On most undertakings a label showing the destination station and route is regarded as providing adequate information for the marshalling yard staff, and the particular siding in which a wagon requires to be shunted at an intermediate yard is usually indicated by chalking before shunting operations are commenced.

The Sudan Railway is divided into fifteen zones and the zone number is superimposed in red on the wagon labels which also indicate the destination station. It is stated that this arrangment is of considerable assistance to the shunting staff.

Special marshalling group labels are used on some sections of the Indian Railways in order to provide indication to the staff of the group into which a particular loaded wagon requires to be marshalled in the train.

Question 2. — *Are arrangements made for advice to be given of the composition of trains before their arrival at the marshalling yards? If so, what are the general arrangements, and is it found that there are advantages in this practice?*

ANSWER.

It is customary on most Railways for an advice to be sent, either by telegraph or telephone, from the departure yard to the receiving yard showing the time of departure and the composition of trains, but the extent of the information transmitted varies considerably with different Administrations.

The more general arrangement is to give either the total number of wagons or the number in each section of a train and to make special mention of wagons conveying such commodities as livestock, perishables, fragile and urgent traffic. The position of such wagons on the train is often indicated in the advice.

In Ceylon the advice is confined to wagons conveying valuables and in New Zealand to livestock. In both these countries no other prior advice of train loading is given.

The Pennsylvania Railroad, the Sudan and the Indian Railways have adopted more elaborate methods of advising. The Pennsylvania messages give the wagon number, lading and final destination, and the Sudan Railways, in addition, also make reference to the contents of the wagons.

In India the message indicates the total number of wagons for each section group. An experiment is being made with a more detailed reporting arrangement associated with the special marshalling labels referred to in the answer to question (1), under which the number of wagons in each of the groups is given. The advantage claimed for this arrangement is that it enables the station ahead to have ready in a suitable position additional vehicles for attaching, and shunting power can be arranged in advance to adjust the load of the train in the most efficient manner with the minimum of detention.

The practical advantages of receiving an advice of the composition of a train before its arrival may be summarised as follows :

(*a*) Clearance of reception roads can be planned to ensure that a suitable road, commensurate with the load conveyed, may be available for the reception of each train as it arrives, thus avoiding congestion on the running lines.

(*b*) Special arrangements can be made for dealing with livestock, perishable and urgent traffics to ensure that the best forward service is given.

(*c*) The information is helpful in determining in advance whether «optional» or extra services will be required and

locomotive power and trainmen can be arranged accordingly. Conversely when the messages indicate that the flow of traffic is subnormal appropriate action can be taken in good time to curtail the scheduled service.

Question 3. — *How do you determine, in the general interests of yard working, the arrival and departure times of trains booked to serve the yard?*

ANSWER.

Although, from the point of view of efficient yard working, an arrangement under which arrivals and departures are spread evenly throughout the time the yard is open would give the most economical results, this is never possible in actual practice. Many other considerations have to be taken into account and it is only after weighing each factor in its proper perspective that a balance can be struck and a decision taken regarding the relative importance of conflicting interests.

In fixing the arrival and departure times of trains, due regard must be paid to the line occupation on the main trunk routes, as it would be wasteful of train crews to start trains at times when a reasonable path for them is not available. The requirements of the passenger service have frequently to be taken into account and on some railways the running of freight trains is prohibited at certain periods of the day when passenger traffic is at its peak.

The transit time of freight traffic is another vital factor. At the majority of loading points, i. e., goods sheds, private sidings, docks, etc., the preponderance of loaded wagons becomes available for despatch during the late afternoon and in order that time may not be wasted at the yards, it is necessary to arrange train departures to lift the traffic as it arises. Similarly, it is desirable that, wherever possible, traffic should be sorted in the marshal ling yards in time for it to be worked to delivery points and placed in position for discharge by the normal starting time of the unloading staffs. In countries such as Great Britain where distances are relatively short, there is a strong pressure from commercial undertakings for goods loaded one day to be conveyed to destination and placed in position for unloading the following morning and this demand for an overnight service militates against the regular interval spacing of departures and arrivals at the marshalling yards.

Consideration must also be given to the efficient user of locomotives and train crews, and in arranging the departure of trains due regard must be paid to the importance of providing a suitable balancing service.

Departures of local freight trains serving small intermediate stations (omnibus trains) must run at times when the stations are normally open for dealing with freight traffic, and similarly the departure of trains serving goods sheds, private sidings, docks and wharves must be related to the times at which work is in progress. Delivery of wagons before the commencement of work in the morning and lifting of traffic after cessation of work in the evening is the usual requirement, but where work is carried on either for two shifts or continuously, arrangements must be made accordingly.

Over-riding factors of this character are common, in one form or another, to most railways but after making allowance therefore, it is still possible to adhere fairly closely to the following basic principles in determining the arrivals and departure times of trains :

(*a*) Arrivals are spaced as evenly as considerations permit and great care is taken to avoid trains arriving in such close succession that the yard cannot accommodate them currently.

(*b*) Departures are arranged to provide for the regular clearance of wagons to all points, either in full loads for one destination yard or to an intermediate yard.

(*c*) The departures to individual destinations are designed to give clearance at times when a full load is normally available, thus ensuring clearance of the sidings concerned before they are filled to capacity.

(*d*) The suitability of the timings must be considered in relation to the requirements at both the despatching and receiving yard — where there is a confliction in the requirements a compromise solution in the best interests of the working as a whole must be made.

(*e*) The planned arrivals and departures must ensure that no traffic is held up for an undue period.

Question 4. — *What organisation has been established to co-ordinate the various yard operations, i. e., reception, examination, checking, numbertaling, marshalling, testing of brakes and the clearance of wagons from adjacent works, goods depots, tranship sheds, etc.?*

ANSWER.

Co-ordination of the various yard operations is the responsibility of an operating official who is usually designated the « Yard Master ». In the execution of his duties, he has the help of Assistant Yard Masters, Inspectors and Foremen, and through them, supervision is exercised at all times when the yard is open.

A general plan for the working of the yard is laid down by the Yard Master under which each member of the staff is made responsible for some phase of the yard working and the aim is to ensure the maximum efficiency with the minimum number of engines and men.

Rosters for engines and shunting staff are arranged to cover the normal traffic, including provision for the delivery to, and the clearance of wagons from adjacent works, goods depots, etc. Normally, the planned arrangements cover overall requirements but the Yard Master makes adjustments on a day-to-day basis to meet any contingencies which may arise.

The Assistant Yard Masters and Inspectors are in constant and direct touch with the actual position in the yard at all times and it is their duty to make whatever minor adjustments to the normal plan that may be necessary to meet fluctuating conditions and to ensure that the accommodation, locomotives and shunting staff are used to the best advantage.

Wagon examination is normally undertaken by the mechanical engineering staff but the Yard Master and his supervisors collaborate and co-ordinate the arrangements in the best interests of the working as a whole.

Question 5. — *On what basis is the siding allocation determined? Is this fixed or varied according to traffic requirements and is the allocation based on one destination only, or are several destinations included in the same siding?*

ANSWER.

In general the siding allocation is determined in such a manner as to reduce to a minimum the amount of second sorting which has to be undertaken to make trains ready for despatch.

Much depends upon the number of sidings available in relation to the number of points for which separations must be made, the relationship between the capacity of the individual sidings and the train load, and the prompt clearance of roads when a train is made up.

At most yards the allocation of the majority of the sidings is definitely fixed but it is not unusual for a small number to serve a dual purpose whilst others may be used for different traffics at certain times of the day. Where it is necessary to cater for special seasonal traffics, the fixed allocation may be varied as a temporary expedient.

There are very few yards where the allocation of the sidings is based strictly on one destination only and it is seldom the case that every siding is used for several destinations. At practically all yards, some sidings are set aside for one destination only (including wagons for another marshalling yard) whereas others are allocated to traffic for several destinations.

Moreover the directional flow of traffic and the relationship with other yards have an important bearing on the matter and,

although it is difficult to generalise, the allocation at a typical yard is usually on the following lines :

Sidings are allocated to :

(*a*) Wagons for specific destinations where there is a regular flow approximating to the equivalent of a train load in 24 hours.

(*b*) Wagons for destinations with a direct service from an adjacent marshalling yard.

(*c*) Groups of traffic which are sent forward to an intermediate yard for subsequent despatch, a separate road being earmarked for each yard to which trains are made up.

(*d*) Stations and works served by local trains where it is necessary to form the wagons in station order. Usually the wagons for each local train are kept together and subsequently remarshalled in the order required, but where the practice of « simultaneous » formation is resorted to, wagons forming the same position in trains for different destinations may be placed in the same road.

(*e*) The principal types of empty wagons.

(*f*) Defective wagons.

Question 6. — *Have you had experience of a bonus system of working for the staff engaged in marshalling yards? If so, what advantages are found to result therefrom? Set out briefly the basis on which the systems are established.*

ANSWER.

None of the Administrations have bonus systems of working for the staff engaged in marshalling yards.

Question 7. — *In your large traffic yards, and under normal conditions of working, are any statistics recorded to show :*

(a) *The average time taken for a wagon to pass through the yard (with information as to how this calculation is arrived at)?*

(b) *The number of wagons shunted per shunting engine hour?*

(*c*) *The number of wagons shunted per hour of duty of staff employed, and is this broken down into the various grades, i. e., pointsmen, numbertakers, staff engaged on braking wagons down, other shunting staff and supervisory staff?*

ANSWER.

(*a*) Only the Indian Railways maintain regular statistics of this description and they are designed to show the average detention to through loaded wagons. This figure is arrived at by recording in wagon exchange registers or similar records the hours of detention to each loaded wagon, i. e., the interval between arrival and departure. At the end of the month the hours of detention are totalled and the total is divided by the number of loaded wagons despatched during the month, due allowance being made for vehicles arriving at the end of one month but not sent forward until the beginning of the next.

At some Indian yards a wagon card index is maintained and these are used as the basis of the statistic instead of the wagon exchange register.

(*b*) With the exception of the South African and Ceylon Railways, statistics to show the number of wagons shunted per shunting engine hour are maintained at most of the larger yards but the methods of compiling and presenting the statistics vary considerably.

On the Sudan Railways, for example, a *Shunting journal* is compiled by the head shunter in charge of each shunting shift, in which the following details are recorded :

Shunting engine number.
Time of departure from Loco. Shed.
Time of return to Loco. Shed.
Shunting performed (showing number of vehicles moved).
Actual shunting time.
Time shunting engine standing under steam.
Time shunting engine running «light».

From this journal, a daily record of all shunting performed is prepared (by

the Yard Master or Station Master), showing the time worked by shunting engines, divided into active shunting time, standing under-steam time and running time, and giving details of the vehicles shunted. This daily return is rendered to District Offices, who, in turn, compile a *monthly* return of shunting hours for all stations, from which the average shunting time for vehicles is calculated.

(*c*) The Indian Railways compile figures to show the number of wagons dealt with per Rs 15/— of wages paid. This statistic is, however, under examination with a view to revision.

On British Railways, weekly statistics are prepared at all the principal yards which show the number of wagons detached per man hour on duty of the shunting staff, but the statistics are not broken down into the various grades. The Return also shows the number of wagons detached per shunting engine hour.

***

PART II.

Control and supervision of work.

Question 8. — *Is there a control post or control agent at the yard and, if so, what are his duties so far as the marshalling yard is concerned?*

ANSWER.

The Yard Master is the Agent responsible for the control and supervision of the marshalling yard work and through him responsibility is delegated to his Assistants or Inspectors so as to provide continuity throughout the time the yard is open for traffic.

In most countries consulted there is a « control post » in the sense that there is a focal point, usually in the Yard Master's office, connected by telephone with all the strategic points in the yard, as well as to the District Train Control Office and adjacent signal boxes, which enables the supervisor to coordinate the yard operations in the best interests of the working as a whole.

The principal responsibilities of the yard supervisor may be summarised as follows :

(*a*) To regulate the yard working to ensure that reception accommodation is available for trains immediately on arrival, thus avoiding congestion on the running lines approaching the yard.

(*b*) To ensure that trains are correctly formed and that they leave punctually.

(*c*) To organise advance planning, by relating the wagons on hand and expected to arrive to the booked service, and to arrange in conjunction with the District Train and Traffic Control for the running of « optional » and additional services when necessary to cater for abnormal flows of traffic. When traffic is sub-normal, appropriate reductions in the booked service are made.

(*d*) To make such adjustments in the disposition of shunting engines and staff as may be necessary to meet fluctuating conditions in the various sections of the yard.

(*e*) To order additional shunting power, when essential, to deal with extra traffic and make reductions wherever possible in the light of the conditions prevailing.

(*f*) To make special arrangements for the prompt despatch of perishable, livestock and other urgent traffics.

(*g*) To supervise the observance of wagon distribution orders.

(*h*) To co-ordinate the working of the yard generally, with a view to making the most economical use of shunting power and avoiding any undue hold-up of wagons.

Question 9. — *What arrangements are made to adjust the staff to the work required, and what arrangements are in force for providing analyses of traffic passing?*

ANSWER.

The general plan for the staffing of yards has in most cases been determined over years of experience and is related to the

physical layout and the normal volume of traffic to be handled. The adjustment of staff to meet variations in the work to be undertaken may best be considered under the following heads :

(a) *Day-to-day fluctuations in traffic.*

The extent to which adjustments can be made on a day-to-day basis depends largely upon staff agreements, whether the fluctuation is constant, e. g., occurs on the same day or days each week, and whether it is in an upward or downward direction.

Insofar as the fluctuation is constant it can be, and is usually, taken into account in preparing the shunting staff rosters. Sporadic day-to-day fluctuations are more difficult to legislate for, but when traffic is so much above normal that it cannot be handled by the rostered staff, the position is frequently met by overtime working in a section of the yard which is, in ordinary circumstances, being operated below full capacity. Another alternative, and one which is frequently resorted to on British Railways during the heavy winter months, is to keep yards open for one or more turns of duty on Sundays, when they would otherwise be closed.

When the fluctuation is in the downward direction, the problem of effecting staff reductions to meet the day-to-day position is a difficult one, particularly in countries where the staff are employed on a permanent basis, with guaranteed wages. In such circumstances the staff are used to the best advantage on miscellaneous jobs, such as cleaning up the yard, mess rooms, stores, etc., but the scope for finding effective work is obviously limited.

(b) *Seasonal fluctuations.*

The probable flow of seasonal traffics, such as fruit and sugar beet, can be determined in advance from previous experience supplemented by reports from the growers, and it is customary to provide for additional shunting power and staff to deal with them. The arrangements usually include the opening up of sections of yards which are normally closed, or closed for part of the 24 hours, and they frequently provide for some redistribution of work between yards, in order to give essential relief to the points called upon to handle the seasonal traffic.

A very close watch is kept on the arrangements to ensure that the additional staff are not provided unnecessarily, particularly at the commencement and termination of the season.

(c) *Permanent alterations.*

The amount of work to be done is under constant review by the Yard Masters, and whenever experience shows that there is a regular increase or decrease in the volume of traffic to be handled, suitable adjustments in the engine power and shunting staff are made. Justification for an increase requires to be presented to the District Operating Officer and by the latter to the Chief Operating Officer before additional permanent appointments are made.

The District Operating Officers review the yard working for which they are responsible from the statistical data of wagons handled and shunted per shunting engine hour, taking into account variations in the number of segregations which require to be made and changes in timetabling which may affect the amount of work to be done. In the light of these considerations conclusions are reached regarding permanent adjustments to shunting power and staff.

(d) *Traffic analysis.*

There are no arrangements in force for providing analyses of traffic passing except in the case of the British Railways where a permanent organisation exists for making periodical tests where and when necessary.

The special records are usually compiled by the Operating Superintendents, staff, with some local assistance, and they cover periods of three to six days or

even longer. The details recorded vary slightly according to the particular purpose for which they are required, but they usually show the wagon number, sending and receiving station, the train and time of arrival and service given on departure.

They form an admirable indication of the efficiency of the yard working as a whole and provide valuable information respecting :

1) The possibilities of increasing the number of through trains designed to give the longest possible runs, thus reducing to a minimum the number of intermediate marshalling yards that wagons require to enter for re-sorting.
2) The desirability of adjusting train timings to conform more closely to the actual flow of traffic.
3) The failure of yards to load wagons to the correct marshalling yard.
4) The detection of delay to wagons in marshalling yards, thereby indicating the need for remedial measures to be taken.

The work involved in recording, summarising and analysing information of this kind is somewhat formidable and for this reason the analyses are undertaken primarily at those yards where it is considered, from the general information available, that there is scope for greater efficiency.

Question 10. — *What is the arrangement for setting up and despatching special trains as may be necessary to provide for the rapid and satisfactory clearance of the marshalling yard, and what is the organisation which provides for the diversion of trains from one destination to another according to traffic fluctuations?*

ANSWER.

In the interests of the efficient user of engines and men, and in order to avoid congestion at yards and on the running lines, it is the practice on most undertakings to schedule regular trains to meet all normal requirements, thus reducing the number of occasions when special working is necessary.

To some extent provision for additional traffic is made by including in the timetable « conditional » trains which run only when justified by a heavy traffic flow. The virtue of this arrangement is that the timing is fixed in advance and provides for a suitable path on the running lines as well as for departure and arrival times convenient to the working at the yards concerned. Special trains are run according to circumstances, but the occupation of the track and the position at the receiving end must be taken into account.

On most of the undertakings consulted, the stock of wagons in the yard, which is usually taken three or four times a day, coupled with information respecting the loads of trains en route, forms the basis of the decision to run a « conditional » or special train. The actual decision usually rests with the District Train and Traffic Control Office, which receives particulars of the yard stocks at regular intervals and takes into account :

(*a*) The availability of engine power and, in particular, the possibility of making use of incoming engines and men who have no rostered return working.
(*b*) The position at the receiving yard.
(*c*) The possibility of providing return loading for the engine and men.
(*d*) The effect on the booked service (the running of a special and subsequent cancellation of a booked train is not normally good operating practice).

As regards the diversion of trains from one destination to another this follows the same procedure as the special train working and the responsibility rests with the District Train and Traffic Control Office, although the Yard Master and his supervisors do not hesitate to make representations to the Control whenever they consider such a course necessary. Perhaps the most important factor to be taken into account when adjusting the booked service in this manner is the loss of return loading at the yard which would normally receive the train to be diverted. The District Controls are well equipped with telephone communica-

tions and, before agreeing to a change of this kind, all the interests concerned are consulted and the course of action is determined by the circumstances as a whole. Particular attention is paid to the effect on locomotives and trainmen, and steps are taken to return to normal diagrammed working as quickly as possible.

Question 11. — *What methods of control are exercised in order to ensure that the yard is operated with efficiency and economy?*

ANSWER.

Initially, responsibility for the efficient and economical working of the yard rests with the Yard Master and his supervisors. They make a close daily scrutiny of the train and yard working sheets, paying particular attention to late starts, light loading of trains, detention of train engines and uneconomical use of shunting power.

They keep a watchful eye on the actual operations to see that wagons are efficiently braked into the sidings to avoid damage, give attention to the regular clearance of the reception lines and control generally the detail of the yard operations.

The District Operating Superintendent is supplied with statistics by which he and his staff are able to criticise results achieved, comparing them with previous periods for the particular yard and with the results obtained in other yards. The District Operating Superintendent, his Assistant, and District Traffic Inspectors visit the yards periodically and regular periodic meetings are held between the District Operating Superintendent and the Yard Masters in his district, at which matters affecting yard working generally are ventilated.

The summarised results are also subject to scrutiny by the principal Operating Officer and attention is directed to any falling off in the standard of performance.

***

PART III.

Checking, numbertaking, etc.

Question 12. — *What is the organisation in operation in regard to checking and numbertaking so far as both arrivals and departures are concerned? What documents are made use of and do the checkers or numbertakers concern themselves with the preparation of « cut cards » or « siding slips »?*

ANSWER.

On British Railways checking and numbertaking is only carried out at the marshalling yards to a very limited extent, it being considered that the heavy cost of providing staff for this purpose cannot be justified by the benefits to be derived from such records. Arrangements exist at most yards for noting the arrival and departure of wagons of livestock, as well as particularly important and valuable traffics, but apart from this, there is no general system of checking and numbertaking.

All the other undertakings consulted have checking and numbertaking arrangements in some form but the procedure varies according to local needs.

In the Sudan, all the vehicles on a train are checked at the starting station by a checker or numbertaker, details of the actual wagon numbers, contents, destination, weight, etc., being entered on a « Train Load » form. Details of wagons arriving on trains and on shunting trips are also recorded.

The South African Railways and Harbours employ numbertaking staff to prepare lists of the vehicles marshalled in each train.

In India numbertakers record the wagon numbers on all trains arriving, indicating the destination and whether loaded or empty. On outward trains, similar information is recorded and the numbertaker prepares a summary for the guard who is required to check its accuracy by comparing it with the make-up of the train. The particulars are recorded in numbertakers' handbooks and, in certain cases, directly on to wagon cards. Particulars from the handbooks are subsequently transferred to the « wagon exchange register ».

On the Ceylon Government Railways numbertakers record the numbers of all wagons received and forwarded, with a note of the sending and receiving station and particulars of the contents. Checkers are also employed in connection with the examination of seals of wagons.

On the Victorian Railways numbertakers record all trains and wagon departures on truck sheets. Similar sheets are compiled by guards of incoming trains and these returns form the basis of register records. Each day's records are checked with those for the previous day and symbols are inserted to indicate the time spent in the yard by each wagon. The attention of the supervisors is drawn to wagons held up for 24 hours or more.

The New Zealand Railways prepare a loading list for every train at the starting station showing the wagon number and class, point of lifting and destination, contents, gross and tare weights, and total tonnage of the train. Particulars of wagons lifted en route are inserted on the loading list by the guard. On arrival at destination station the wagon numbers are checked by the numbertaker with the loading list, a copy of which is retained by him and handed in to the Yard Master. A check is simultaneously made with the invoices to see that each wagon is accompanied by the appropriate documents. A similar check is made at the starting station.

It will be seen that each Administration adopts the methods of checking and numbertaking best calculated to meet its own particular requirements and no doubt the liability to loss from pilferage has an important bearing on the matter.

None of the Administrations consulted utilise checkers or numbertakers to prepare « cut cards » or « siding slips ».

Question 13. — *How is the work of the checkers and numbertakers supervised? Is it under the control of one chief numbertaker or checker who details the duties of the staff under his charge, or does it fall within the responsibility of the organisation referred to in Question (8)? If so, what are considered to be the advantages of this arrangement?*

ANSWER.

At yards in India where several numbertakers are employed they are supervised by a head trains clerk and the Victorian Railways employ a special yard checker to supervise the numbertakers.

Apart from these exceptions, the work is supervised by the Yard Master and his Assistants.

Question 14. — *What method is in operation for dealing with commercial and other documents which accompany the wagons in cases where they are required at the yard master's office, or at some other point for documentation purposes?*

ANSWER.

On British Railways and most of the other undertakings consulted, commercial and other documents are not made use of by the marshalling yard staff and consequently they are not interfered with in any way. In the case of less than wagon load consignments passing through tranship sheds, the documents are received, either on the wagon side or by passenger train at the tranship shed, where they are sorted and re-distributed to the wagon in which the traffic is reloaded.

The Pennsylvania Railroad use a messenger service for transferring the documents, whilst the New Zealand Government Railways arrangements provide for the documents being dealt with through the Yard Master's Office. On the Sudan Railways the documents are entered on a guard's waybill form and this, together with the documents themselves, is handed over to the guard (against signature). They remain in his personal care and are handed over to the yard staff at the end of the journey, when a receipt is obtained for them.

***

PART IV.

Examination and repair of wagons.

Question 15. — *How is the examination of wagons undertaken? On which roads (reception, sorting or departure) is this generally carried out? What is the proportion of wagons actually found to require attention on examination in the reception sidings on the one hand, and in the sorting or departure sidings on the other? What is, in your opinion, the most satisfactory arrangement for the examination of wagons?*

ANSWER.

It is the general practice for this work to be undertaken by wagon examiners, who inspect both sides of the wagons for defects, heated bearings and so on.

In almost all countries wagons are examined twice as they pass through a marshalling yard, firstly, when they arrive in the reception sidings and, secondly, in the sorting or departure sidings after the shunting operations have been completed.

There are, however, exceptions to this, for example, the Pennsylvania Railroad concentrates most of the work on the reception roads. Upon arrival of a train, blue flags by day and blue lights by night are placed at each end to afford protection for the car inspectors. Two sets of two men each are normally assigned to make the inspection and minor defects are attended to at once. Where the defects require more substantial adjustment the cars are labelled for transfer to the « shop track » for attention. In the departure yards, the air brakes only are tested before departure of the trains.

Although in most British Yards examination is carried out on arrival and again before departure, an exception is made in the case of certain flat yards where examination is only undertaken once, usually before departure.

As a general rule, examination of trains on arrival and again before departure is favoured. The value of the first examination is that hot bearings are more easily detected, repairs can be taken in hand more quickly and defective wagons can be shunted into the « repair road » for attention as the shunting of the train is carried out. The second examination is necessary to detect any defects arising from shunting operations in the yard.

Statistics are not available on any of the undertakings (except the Ceylon Government Railways) to indicate, separately, the proportion of wagons found to require attention on the reception sidings and in the sorting or departure sidings. The combined figure for British Railways is approximately 1 % but it ranges rom as little as 0.25 % to as much as 2.45 % according to the type of yard and nature of the traffic. The Victorian Railways note a figure of 5 %.

The Ceylon Government Railways state that 6 % of the wagons on reception lines and 6.7 % on outward lines require attention

Question 16. — *Is the work of the examiners controlled by a chief examiner who organises the work of the examiners, or is this work controlled by the organisation referred to in question (8)? If, on the other hand, there is some other method of control, please give a brief account and say what, in your opinion, is the best organisation to be adopted in regard to wagon examination generally?*

ANSWER.

The wagon examiners are technical staff and are controlled by their parent department — usually the mechanical engineer or the carriage and wagon engineer.

The wagon examination staff are usually supervised by a chargehand or foreman examiner who arranges the plan of work. There are no cases where the work is supervised by the Yard Master but there is very close co-operation between the two departments to ensure the fullest benefit to the working as a whole.

Question 17. — *Are there one or more sidings especially allocated for light repairs to wagons? If so, state the advantages, if any, of this arrangement.*

ANSWER.

It is almost invariably the practice to allocate one or more sidings for carrying out light repairs to wagons and to rectify damage which may occur in transit or in shunting operations.

The arrangement permits of the wagon repair staff making adjustments without fear of interference from shunting movements, it avoids the loss of time which would otherwise be taken in transferring the wagons to and from the shops and allows of each wagon continuing its journey with the minimum loss of time.

***

PART V.

Shunting.

Question 18. — *How are the operations preparatory to actual shunting carried out?*

ANSWER.

The usual operations preparatory to the actual shunting comprise the following, which are carried out in the manner indicated :

(*a*) The load is secured and the train engine is liberated to the shed or to pick up a return load from some other point in the yard. When urgent wagons are marshalled on the front the train engine is frequently used to take them to the point where they are required.

(*b*) The wagon examiners inspect the train and mark any wagons required in the « repair » siding for attention.

(*c*) A senior member of the shunting staff chalks on each rake of wagons the number of the siding into which they are to be shunted. At mechanical yards a « cut card » is made out and despatched to the control tower.

(*d*) The automatic brake is destroyed.

(*e*) In the case of a hump yard the wagons are uncoupled between the various « cuts ».

Question 19. — *What are, in your opinion, the best means of securing the most satisfactory results in terms of wagons shunted and in spreading the work in such a way as to avoid idle periods or train detentions?*

ANSWER.

Apart from questions of layout, which are outside the scope of this review, the most satisfactory results are achieved by designing the train arrangements to provide a fairly even flow of incoming and outgoing trains. For the reasons given in answer to question (3) this is not always possible but as regards inward trains the difficulty can be overcome by the provision of adequate reception roads. In addition to avoiding congestion on the running lines, they provide a reservoir of trains waiting shunting for the staff to draw on when they would otherwise be idle owing to irregularities in the arrivals.

It is equally desirable that the yard should be cleared of trains as they are made up ready for departure, otherwise the sidings become congested and the rate of shunting is impeded. When, therefore, pathing difficulties or availability of motive power require that train loads should be held up for a time, departure roads should be provided.

It is also important that the length of the main sorting sidings should be adequate for the purpose for which they are used and where possible, there should be some margin of reserve to meet contingencies.

Much can be done, by effective supervision, to make use of intervals between the arrival of trains requiring to be shunted by closing up roads, correcting wrong shunts and taking the fullest advantage of slack periods to carry out second sorting with a view to saving time required for this work later on.

Question 20. — *Does your organisation provide for the special handling and despatch of urgent wagons? If so, how are these wagons dealt with and does this adversely effect the working of the yard as a whole?*

ANSWER.

All the Administrations provide for the special handling and despatch of urgent wagons.

The more general arrangements provide for the selection of the services which will give the most expeditious transit and special precautions are taken to see that such wagons are shunted, out-of-turn where necessary, to ensure that connections are made.

It is often found advantageous to marshal the wagons next to the engine, so that the train engine may take them forward immediately to the point in the yard where the transfer is to be made; for instance, in a hump yard the engine can take them through to the departure end of the yard without the wagons having to take their turn in being passed over the hump.

It is customary for particulars of urgent wagons to be given on the train wires and the information is passed forward from yard to yard.

The effect on the yard working as a whole depends largely upon the extent to which wagons of this description require to be dealt with. Obviously, the effect must generally be unfavourable, but the replies indicate that the volume of traffic so dealt with is relatively small. It is pointed out that the arrangement not infrequently causes late starts to trains with which connections have to be made.

Question 21. — *What is the extent of the interruption to shunting resulting from such cases as correcting wrong shunts, closing up of wagons in the sorting sidings, locomotive duties, train departures, etc.? How does this time compare with actual shunting time and what steps are taken to reduce this to the minimum?*

ANSWER.

The extent of interruptions to shunting from these causes varies considerably from one yard to another according to the type of yard and the form of shunting power in use.

None of the countries consulted have regular statistical data on this point and, although some undertakings consider the loss of time is relatively small, it probably amounts to about 25 % in most yards, although it is probably less where diesel or electric engines are employed.

Closing of wagons is probably the greatest single cause of interruption and it is difficult to find a complete solution, as faster running may lead to increased damage. The use of an additional engine is sometimes advocated, but it is a costly remedy and not always entirely satisfactory. In the countries consulted, capstans are seldom used and limitations of space between roads precludes the use of tractors.

Time occupied in correcting wrong shunts can be minimised by careful attention to the chalking and preparation of cut cards and by avoiding excessive speeds in propelling over the hump.

A reduction of time on locomotive require ments can most readily be secured by the use of diesel engines, but failing this the careful siting of water columns and coal stages is helpful. Where several engines are in use, it may be economical to use a relief engine. Apart from these considerations much can be done to minimise the loss of effective time by arranging for locomotive requirements to be taken at slack periods and when shunting has to be discontinued to permit of train departures.

Question 22. — *What precautions are taken to guard against rough shunting and derailments?*

ANSWER.

The first essential is that the rate of shunting should be properly related to the physical conditions, i. e., gradients, curves, and wagon resistance, and to the facilities for braking, due regard being paid to the staff normally provided for this purpose. At yards where the incidence of damage and derailment is abnormal, detailed investigation frequently indicates the need for better co-ordination of these factors. In some cases a solution has been found in

minor modifications to the layout and by improved lighting at strategic points.

Whatever the form of layout, freedom from damage and derailments must depend to a large extent upon the experience of the shunting staff and the skill with which they carry out their duties. Towards this end, most of the undertakings consulted issue instructions to the staff and care is taken in the selection of suitable men and in training them in their duties.

A high degree of supervision is an important factor, and this is normally exercised by the Yard Master and by the Inspector or foreman in charge of each group of sidings. Usually, all derailments are the subject of enquiry by the Yard Master to determine the cause and the responsibility in order that remedial or disciplinary action may be taken to avoid a recurrence. It is also the practice to report all cases of damage with a note of the causes.

In the case of fragile goods which are particularly liable to damage in shunting, it is the usual practice to provide distinctive labels in order that special attention may be drawn to the need for care being taken when dealing with them.

Question 23. — *What arrangements are made to deal with wagons which have been shunted into the wrong siding, damaged wagons and wagons whose loads require attention or adjustment? What is the percentage of wrong shunts?*

ANSWER.

The arrangements for correcting wrong shunts vary at different yards and they are invariably designed to meet the local conditions. In the majority of yards the correction is made by the shunting engine at the sorting end of the sidings at a time when this can be done with the least interference with shunting operations. When the position of the misplaced wagon is convenient and power can be made readily available, it is not unusual to make the correction at the departure end of the sorting sidings. The transfer of wrongly shunted wagons is frequently undertaken during a break in the shunting when closing up operations are in progress.

It is customary for damaged wagons and those with displaced loads to be shunted into the siding or sidings specially allocated for carrying out repairs and reloading.

Most of the Administrations consulted report that although no figures are available, the number of wrong shunts is very small. In Britain considerable variation is shown between yards and the number of wrong shunts varies from 0.05 % to 0.5 %.

Question 24. — *How are wagons closed together for coupling up? Have you had any experience of the use of tractors working on the ground alongside the rails, or of rail tractors, or of any other such appliance? If so, please give details and say whether they have proved satisfactory.*

ANSWER.

All the Administrations consulted make use of engine power for closing up wagons in marshalling yards. The work is usually performed by the shunting unit but use is also made of train engines.

Although use is frequently made of capstans for closing up wagons in goods sheds, and the Victoria Railways use rail tractors working on the ground alongside the rails for the movement of wagons in goods yards, there are no instances where these appliances are used in marshalling yards.

***

PART VI.

Braking and retarding arrangements.

Question 25. — *By what means do you brake or retard wagons :*

(a) in yards equipped with rail brakes,

(b) in other yards,

and, in particular, how is the staff engaged in braking and bringing the wagons to rest distributed?

ANSWER.

(a) *Yards equipped with rail brakes.*

Rail brakes are located on the first three or four sections of track immediately fol-

lowing the crown of the hump and sufficient pressure is exerted to ensure adequate spacing between the « cuts » to avoid overtaking due to the different running qualities of wagons. The retarders are operated by men located in what is usually termed the « control tower ».

After this initial braking, only one further braking zone is required and here the momentum of the wagons is regulated, usually by the hand brakes, but sometimes by skids. This second braking is undertaken in the sorting sidings and one brakesman controls the wagons in a section of 10 to 12 roads.

Very few of the yards in the countries consulted are equipped with rail brakes.

(b) *Other yards.*

The general practice in yards not equipped with rail brakes is to make use of the hand brakes which are usually operated by a hand lever placed in a convenient position on each side of the wagons. In Britain the brakesmen are equipped with a short stout stick with which to exert greater pressure on the brake lever than can be made by hand.

In some yards skids or brake slippers are used, but they are the exception rather than the rule, being confined to a small number of hump yards.

The distribution of the shunting staff is varied according to the layout of individual yards. The general practice in hump yards is for the leading shunter to control the movement of the shunting engine and to manipulate the king points, another shunter (or shunters) controls the points in the next sections, assisted frequently by a brakesman, to prevent the cuts overtaking one another. The braking is undertaken in the sorting sidings by junior shunters, each taking responsibility for a group of sidings. These men usually take up a position close to the points at the sorting end of the group.

In flat yards the customary procedure is for the leading shunter to uncouple the various « cuts » and to signal to the driver of the shunting engine. A second shunter is responsible for manipulating the points and at some yards one or more brakesman are employed to manipulate the hand brakes as may be necessary.

On the Sudan Railways loose shunting of wagons is not permitted.

Question 26. — *In the case of hand operated skid brakes, do you rely upon the experience of the staff or are instructions issued in regard to the length of skid to be allowed?*

ANSWER.

At places where hand operated skid brakes are used it is the invariable practice to rely on the skill and experience of the staff concerned.

The determining factors, i. e., gradient, curvature, number of wagons in the sidings, state of the rails, weight of wagons and the number in a rake, vary so much that experience is a more reliable guide than any predetermined formula.

Question 27. — *In the use of hand operated skid brakes, do you work on the principle of bringing the wagon to rest short of the preceding wagon in the siding so that the wagon may then move forward by gravity at such a speed as to bring it only very gently on to the preceding wagon? If so, how is this arranged?*

ANSWER.

The procedure is to bring wagons to a rest short of the preceding wagon in the siding. The skid is placed at a suitable distance from the last wagon in the siding to permit of the shunt gravitating gently foward, after the skid is removed, until contact is made with the other wagons.

Question 28. — *What is the proportion or percentage of wagons damaged either as the result of shunting or derailments? Is it lower in those yards where the methods referred to in question (27) can be applied?*

ANSWER.

Very little use is made of skids in the countries consulted and the experience is

so limited that it is impossible to form definite conclusions. On the whole, the balance of opinion indicates that braking by the use of the hand brakes, with which all wagons are fitted in Britain, is efficient and less costly in braking staff than skid shunting.

Apart from the British Railways, no particulars are available to indicate the proportion of wagons damaged or derailed in shunting but it is said to be very small. In Britain special records have been taken from time to time. They show a considerable difference between yards, the lowest is 0.04 % in a flat yard and the highest 0.1 % in a gravity yard. No figures are available to indicate the effect on liability to damage where skids are used.

***

PART VII.

Formation of trains.

Question 29. — *What is the general organisation in regard to the make-up of trains? Is this arranged in conjunction with scheduled train arrivals and the anticipated time at which these trains will have been disposed of?*

ANSWER.

The organisation regarding the make-up of trains is an integral part of the overall train planning programme. It is based on experience coupled in Britain, with information derived from periodical analyses of traffic flows. The formation to be observed in each case is laid down either in the working timetable or ancillary documents. These planned arrangements may be adjusted from day to day to meet fluctuating conditions by the District Train and Traffic Control staff who are in close contact with the Yard Master.

The extent to which trains are required to be formed in a particular order depends upon a number of factors. In many cases the process of shunting into the sorting sidings satisfies all that is required, e. g., wagons intended for one destination or for another marshalling yard, full train loads of coal and train loads of empties to colliery or port.

In order to expedite transit and to relie congestion at intermediate yards, many the important freight trains are require to be marshalled in sections in a pre-dete mined order and this is laid down in th marshalling instructions. They are relate to the scheduled train arrivals and the tim at which incoming traffic can be mac ready for departure. It is frequently th case that services for the conveyance important streams of traffic are laid dov in advance and the arrangements provi for the traffic being marshalled to facilita exchange from one train to another intermediate yards.

The problem of making up trains servi numerous intermediate stations is rath more difficult, as traffic for each point mu be marshalled together in the order mo convenient for detaching en route. Detail second sorting must, therefore, be undert ken before such trains are despatched.

Question 30. — *In order to obtain the m efficient and economical method of worki is the make-up of trains left to the experie and initiative of the staff or are they requi to work to a pre-arranged programme?*

ANSWER.

Apart from the two exceptions mention later, all the Administrations consul require the staff to work to a pre-arrang programme in the make-up of trains. T instructions are set out either in the work time table or subsidiary publications. is claimed that where traffic flows are fai regular, this procedure produces the m efficient and economical method of work as regards the yards themselves, the use train engines and crews and relia service to traders.

The South African and Sudan Railw rely to a much greater extent on the exp ience and initiative of the yard staff.

In practically all cases the District Cont are empowered to adjust the booked wo ing when necessary to meet traffic fluct tions.

Question 31. — *Have you had experience of a system of « simultaneous formation » under which a number of trains are prepared at the same operation, i. e., the wagons for the first portions of three of four trains are set successively in one siding, the second portions for the same trains in another, and so on, in such a way as to have the sections of three or four trains ready to be attached on arrival of the train engines? If so, have any advantages or economies been found to accrue from this arrangement?*

ANSWER.

The Victorian and New Zealand Railways are the only undertakings which use the « simultaneous formation » system of marshalling. It is regarded as a successful method of train formation which conserves siding accomodation and reduces the number of shunting movements to a minimum.

Question 32. — *What arrangements are adopted so far as the provision of brake vans is concerned, and how are wagons from adjoining depots, such as tranship sheds, wagon repairing depots, etc., incorporated into the trains?*

ANSWER.

Brake vans arriving on incoming trains are invariably used for outgoing services and where the number of terminating and starting trains is equal, no adjustments are necessary. Yards which despatch more trains than they receive require assistance and this is provided for in the control organisation under which arrangements are made for the transfer of brake vans from yards which have a surplus.

It is frequently the practice to allocate a siding to accommodate brake vans but the actual method of placing them on the trains varies with the type of yard. In the case of single ended yards, it is customary to place a brake van at the end of each siding immediately after the departure of the train occupying it. In double ended sidings the van is usually placed on the train by the shunting engine when marshalling has been completed, although in some yards the vans can be gravitated on to the trains.

Local trains or trip engines are arranged to lift traffic from adjacent works and depots and the traffic follows the same course as that arriving on any other service. Where particularly urgent traffic is concerned, arrangements are sometimes made for it to be placed on the front of an outgoing train by the trip engine.

Question 33. — *In cases where there are one or more groups of departure sidings, how is the work distributed between these yards and also between these sidings and the main sorting sidings?*

ANSWER.

The most common case where trains depart from more than one group of sidings is in those yards which are located intermediately on main trunk routes and, because of their location, deal with streams of traffic flowing in opposite directions, i. e., one north to south and one south to north. In such cases the distribution of the work between the yards is according to the traffic flow.

Apart from this distinction it is frequently the case that in addition to what may be termed the main sorting sidings, there may be one or more groups of subsidiary sidings in which the roads are usually shorter. In certain countries, these sidings consist of additions which have been made over the years to supplement original installations outgrown by increases in traffic.

The general arrangement, where subsidiary groups are provided, is to use the main sidings for the normal sorting and to allocate the smaller groups for resorting traffic which must be marshalled in a specific order, for example wagons for roadside stations, local works, private sidings, etc.

The principal distinction is, therefore, that the main sidings are used for the more important heavily loaded trains and the secondary sidings for local trains which convey relatively small loads.

***

PART VIII.

Shunting engines.

Question 34. — *How is the selection and power of the type of shunting engine to be employed determined? Have you had the opportunity of comparing the steam engine with a diesel, a diesel electric or an electric locomotive of similar power? If so, with what results?*

ANSWER.

The selection of the type of shunting engine to be used is determined by the weight of the trains to be handled and the gradients to be negotiated. Several of the undertakings consulted have only two or three types available and the choice is, therefore, rather restricted.

The engines used for hump shunting should be capable of propelling the heaviest train at the uniform speed necessary to conform to the rate of shunting for which the track and braking facilities are designed. On all shunting engines, the following are desirable features :

(*a*) rapid acceleration and deceleration.

(*b*) adequate braking power, preferably on all wheels, to obtain the maximum adhesive factor.

(*c*) quick-acting reversing gear.

(*d*) unrestricted view from the footplate, both to the front and rear.

Most countries have built special types of engines to meet these requirements. In British yards the usual type is 0-6-0 tank, but in some of the heavier yards 0-8-0 and 0-8-4 tanks are employed. The New Zealand Government Railways provide a 2-6-2 tender engine built specially for shunting but 4-6-4 tanks originally designed for short distance suburban passenger work are also used. The Victorian Railways have three types of shunting engines with tractive efforts varying from 19,000 to 21,840 lbs.

Comparisons of steam engines with diesel and diesel-electric have been made on the British and the Sudan Railways and in all instances the performance of the latter compares very favourably with steam engines of similar power. They have many advantages over the steam engine, viz :

(*a*) Saving in staff costs, as only one man, instead of two, is employed on the footplate.

(*b*) Ability to continue at work for lengthy periods, up to one week, without requiring mechanical attention or replenishment of fuel.

(*c*) Quicker rate of acceleration.

(*d*) Greater degree of manœuvrability.

(*c*) Reduced maintenance charges and saving in fuel costs.

Although exact comparisons are not available, experience indicates that a diesel engine is capable of dealing with approximately 25 % more wagons than a steam engine under equivalent conditions.

The South African and New Zealand Railways are experimenting with diesels but so far little experience has been obtained. The Victorian and Ceylon Railways have diesel engines on order.

From the experience which has already been gained, there can be little doubt that diesel engines will gradually replace steam engines for shunting purposes at yards where the work is continuous.

None of the undertakings use electric engines for shunting.

Question 35. — *How many men are employed with the types of shunting engine referred to in Question (34), i. e., footplate staff and other staff working with the engine (shunters, pilot guards, etc.)?*

ANSWER.

The invariable practice is to employ two men on the footplate of steam engines — a driver and a fireman. On diesels only one man is employed.

Leaving out of account the shunters who turn the points and brake the wagons, shunters and pilot guards do not work with the shunting engines except when making transfer trips from one part of the yard to another.

Question 36. — *How do you provide for a continuity of work during the time the shunting engine is standing for the purpose of taking coal, water or locomotive duties, either at the shed or in the yard?*

ANSWER.

The practice varies considerably according to local circumstances. At some yards where several engines are employed they are released to go to the shed every 16 or 24 hours and they are replaced by a fresh engine before the first engine leaves the yard. Under this arrangement the releases are staggered to avoid more than one engine having to be replaced at a time. A somewhat similar arrangement is to provide a relief engine which takes over the work of each shunting engine in turn during the time it is at the shed for locomotive purposes.

At yards where the shunting is not so heavy the engines are liberated periodically, usually at the time when work is slack and the absence of the engine is unlikely to cause undue difficulty. In isolated cases a local trip or train engine may be rostered to relieve the shunting engine for locomotive duties.

Water columns are carefully sited at the most suitable points in yards to permit of water being taken with the minimum interference with shunting operations.

Question 37. — *To what extent is shunting in marshalling yards performed by train engines and under what conditions? Is it considered that advantages can under certain conditions be secured by this arrangement?*

ANSWER.

At large yards it is not usual for train engines to perform shunting except perhaps to the limited extent of relieving shunting engines when the latter are taking locomotive duties, closing a road up prior to depart ing with a train, and for picking up loads from two or more sidings in order to form a train for departure.

A noteable exception is that of Mottram — a large yard in the Eastern Region of the British Railways — where the contour of the ground is such that it has been possible to lay out the sidings to permit of all the shunting being carried out by gravity and without the use of shunting engines. In this case the train engines have to undertake a small amount of yard work, e. g., the shunting out of damaged wagons, displaced loads, and the marshalling of urgent wagons on the front of the train when this is necessary.

In the case of the smaller yards, where continuous shunting engines are not provided, train engines may be called upon to do a limited amount of shunting.

The principal advantage of using a train engine for the strictly limited operations referred to lies in its convenient location at the right time to do a particular job.

Question 38. — *What steps are taken to ensure that shunting engines are utilised to the best advantage and to full capacity, and how are they controlled in their work?*

ANSWER.

The number of shunting engines and the periods which they are required to cover at each yard is laid down in advance, the programme being based on the normal volume of work to be undertaken. It is usual to issue this information in the form of a printed pamphlet or circular and the requirements are revised as necessary to meet seasonal changes and those of a more permanent character. In reviewing the requirements, the results disclosed by the statistical data of wagons shunted per engine hour during recent months are taken into account and whenever new train schemes are introduced, the effect on yard working is considered in relation to the effect on shunting power.

Day-by-day supervision of shunting power is exercised by the Yard Master and his Assistants, who do not hesitate to return an engine to shed for a period when it can be dispensed with.

***

PART IX.

Economy to be realised when the number of wagons to be dealt with is less than the complete capacity of the marshalling yard.

Question 39. — *During periods of falling or reduced traffics, other than day-to-day fluctuations, what means are employed to effect economy? Is it considered preferable to reduce the normal rate of shunting by reducing the number of engines and staff employed, or is it considered better to close down entirely one or more parts of the yard for a number of hours per day? What are considered to be the advantages or disadvantages of these two alternatives?*

ANSWER.

A variety of methods is used in Britain to effect economy when there is a fall in traffic, the principal being :

(*a*) the complete closure of a yard.
(*b*) closure for one or two shifts.
(*c*) closing of a group of subsidiary marshalling sidings at a yard.
(*d*) where two engines are normally employed, one may be dispensed with entirely or for a number of hours per day.
(*e*) an extension of the hours during which a yard is closed or partially closed at week-ends.
(*f*) the withdrawal of the relief engine which covers locomotive duties, where one is provided.
(*g*) the release of a shunting engine, for periods, to cover local trip working, thus saving a local traffic engine.

The extent to which these arrangements can be implemented depends upon the nature of the fall in traffic, the effect on train working generally and on other yards and on the local conditions at the yard concerned.

Where conditions permit, it is preferable, from the purely operating viewpoint, to close a yard entirely or for a complete shift, as this gives the greatest saving in engines and men. But, the effect on transit time must be taken into account and, although there are isolated cases where yards have been closed for a shift, it is usually found that a reduction in the normal rate of shunting, by reducing the number of engines and staff employed, affords the most reasonable solution.

The Victorian, South African and New Zealand Administrations report that they are very little affected by traffic fluctuations. The Pennsylvania Railroad adopts both methods according to local circumstances.

Question 40. — *When it is a question of traffic being light on one or two days only in the week, i. e., Saturday, Sunday or Monday, do you close down certain parts of the yard during these days and under what conditions? If this involves the cancellation of certain trains, which classes are those first to be cancelled? Please comment on the advantages and disadvantages of these partial yard closures.*

ANSWER.

The adoption of the five-day working week by many of the industries in Britain has had the effect of reducing appreciably the volume of traffic for conveyance on Saturdays and Sundays, and it is the practice to balance this by arranging for the total or partial closure of the yards at the week-ends. Many of the yards are being closed from 6-0 a. m. on Sunday to 6-0 a. m. on Monday but the actual period of closure varies at different yards. The position is reviewed immediately before each week-end, in the light of the general traffic conditions, when a decision is made respecting the extent of the closure to be effected.

As regards the cancellation of trains, the time table provides for fewer trains on Sundays than on other days of the week and there are many services which are not planned to run on Saturdays and Mondays. This advance planning is based on past experience of the traffic flows at week-ends, and it is this factor which determines the particular trains not required to run on Saturdays and Mondays.

The position is examined prior to each week-end in relation to the circumstances then obtaining, and further trains may be cancelled if the position warrants such a course. Subject to the proviso that important trains normally conveying urgent and perishable traffic are maintained, the determining factor is invariably the quantity of traffic offering for conveyance, and the trains to be cancelled first would be those for the directions in which traffic was lightest.

The advantages of a partial closure at the week-ends are :

(*a*) an appreciable saving in fuel and wages costs. The fact that a higher rate of remuneration is paid for Sunday work has an important bearing on the savings made.

(*b*) the cessation of work permits of signal boxes being closed.

(*c*) the staff are given a rest day which is beneficial from the health point of view.

(*d*) it provides an opportunity for the engineering staff to carry out repairs and renewals, unhampered by movements of traffic.

The disadvantage of closing down is that traffic is delayed, but in a country like Britain where distances are relatively short, and many firms, because of the five-day week, do not accept traffic on Saturdays and Sundays, this may be more apparent than real.

The Pennsylvania Railroad closes down sections of yards when the volume of traffic justifies such a course. The trains cancelled first are slow freight, mineral and local services.

Most of the other countries consulted do not meet with much difficulty owing to traffic fluctuations and no special measures are taken.

Question 41. — *During a prolonged period of very low traffics, is it found possible to close certain yards either entirely or partially? What would influence you in your decisions in this case, and how would you assess the consequence of these closures?*

ANSWER.

Only in the most exceptional periods of very low traffics would it be possible to close a large marshalling yard down altogether, but small and intermediate yards can often be closed and, in point of fact, there are numerous instances in Britain where this has been done during the past year. At the large yards partial closures have been made in some cases.

A decision would be based on the economies to be realised in relation to the possible adverse effect on transit time of important traffic.

In any scheme for the closing, or partial closing, of a yard one of the preliminary steps is to ascertain exactly what traffic is concerned and to plan alternative methods of dealing with it, usually through adjacent yards. From such an analysis the effect on transits can be assessed and special arrangements formulated to eliminate the most objectionable features.

[656 .212 .5]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

15th. SESSION (ROME, 1950).

QUESTION III.

New technical methods adopted for the design and construction of large marshalling yards.

Lay-out and equipment :

Site and importance of siding groups ;
Lay-out of connections at entrance to groups ;
Longitudinal and cross sections ;
Braking installations (Retarders) ;
Control of point (switch) operation ;
Telecommunications ;
Lighting ;
Staff buildings, etc.

REPORT

(Aústria, Belgium and Colony, Bulgaria, Czechoslovakia, Finland, Greece, Hungary, Jugoslavia, Portugal and Colonies, Rumania, Spain, Sweden and Turkey),

by J. Van Rijn,
Ingénieur en Chef à la Direction de la Voie de la Société Nationale des Chemins de fer belges.

Of the Railways who replied, a fairly large number stated that they could not give any useful information either because they have no marshalling and making up yards, or because they have not made any interesting modifications to their installations in the last twenty years.

Our report is based solely upon the replies received from the Austrian State Railways, the Belgian National Railway Company, the Finnish State Railways, the Portuguese Railway Company, the Mozambique Colony Railways and the Spanish National Railways (R.E.N.F.E.).

We will follow the same order as the questionnaire; consequently we dot not think it necessary to reproduce the questions.

Siting and importance of the groups of sidings.

The various shunting yards built or modernised by the above mentioned railways during the last 20 years are given in Table I which sums up the information received from these railways about each one of them.

Double yards are rare; when the configuration of the railway and the distribution of the traffic makes it possible to find

suitable and sufficiently large sites, single yards in different places are preferred to double yards; the latter should only be considered when the importance of the local traffic (traffic from a port for example) or the extent of the district served, due to the configuration of the railway, results in more traffic than can be dealt with in a single yard. They can also be justified when there are two distinct traffic currents, with no exchanges of traffic between them.

The traffic limit of a single yard is considered to be 3 000 to 3 600 wagons at peak periods. In the particular case of Pasila yard, in Finland, a double yard was preferred although there are only 1 400 wagons, because the whole of the work is done at night.

The essential elements of the making up yard are the reception sidings and the marshalling sidings, placed one after the other whenever the site is big enough. The

TABLE I. — **Marshalling yards built or modernised since 1929.**

YARDS	Peak traffic					Number of tracks				
	Number of wagons coming in in 24 hours	Number of trains received and shunted in 24 hours	Total number of trains sent out after shunting in 24 hours		Number of trains sent out in 24 h. from the departure group of sidings	Reception sidings	Shunting sidings	Making up sidings	Departure sidings	Relief sidings
			without geographical making up	with geographical making up						
Austria :										
Salzbourg-Gnigl	2 000	40	5	42	—	6	21		—	—
Wels	4 000	70	15	55	—	9	30		—	—
Belgium										
Antwerp North (B) ..	2 085	41	39	7	19	7	36	36	10	—
Antwerp North (C) ..	1 990	47	42	2	14	20	36	36	6	—
Châtelineau	2 200	64	32	30	?	18	32	44	12	—
Courtrai	1 360	37	16	18	33	8	30	36	6	6
Haine-Saint-Pierre ...	1 800	43	22	23	—	14	32	32	—	—
Kinkempois	3 200	81	40	40	?	22	46	62	17	—
Monceau	2 400	62	36	20	30	20	32	53	21	—
Ronet	2 600	59	45	19	15	15	33	40	8	—
Saint-Ghislain	2 350	59	17	20	39	16	32	44	12	—
Schaerbeek	3 000	59	35	38	24	31	53	53	24	—
Voroux-Goreux	1 525	38	23	16	—	8	24	24	—	—
Spain :										
Alcazar.............	740	14	10	2	8	6	21		8	—
Zaragoza	650	11	3	13	14	9	30		9	—
Valencia	858	28	35		—	8	28		12	—
Finland :										
Kouvola	1 750	51	51	—	25	10	22		5	—
Pasila	700	20	—	20	—					
Pieksamaki	1 300	40	35	5	30	8	12			

marshalling yard is often also used for making up. In Belgium the marshalling sidings are grouped for this reason on the opposite side to the shunting hump, into a variable number of sections each with an independent access road each of which can be used as a making up yard. In addition a certain amount of making up is done at the shunting hump, when there is not much shunting going on though the making up control post is very busy.

The number of making up yards is determined after a very detailed study of the traffic; in principle there should be as many as there will be shunting locomotives working at the same time. This usually means three making up sidings per marshalling hump (see Fig. 1), when half the trains are made up geographically, taking into account all the duties of the making up yard.

Where the importance and special features of the local traffic justifies having a separate group of sidings, this group is also used for geographical making up, to relieve the main group. This group is usually sited by the side of the marshalling sidings. At Sacavem yard (Portugal), two small geographical marshalling groups of sidings will be provided, directly connected with a departure group (Fig. 2).

The various Railways who replied provide sidings for trains waiting to leave. Sometimes these sidings are grouped into a separate group, and sometimes they are part of the marshalling and making up groups, although in this case they are not connected up with the shunting hump. This arrangement, which is very widespread in Belgium, means that the making up yard will have the shape shown in diagram form in Figure 1.

When the waiting sidings are completely distinct groups, it is better to site them as an extension to the marshalling and making up groups, in order to limit the amount of shunting involved.

Reliefs of passing trains take place in the reception sidings, or the departure sidings, when there is a separate group of sidings for this purpose. A special group of sidings is only provided when such relief takes place frequently without any wagons being left or collected; the siting of this group of sidings depends upon local circumstances.

Only the Mozambique Railways report having made special provision in the marshalling yards to send registered wagons directly from the trains bringing them in to the trains which will take them away.

Various steps are taken to prevent as far as possible interference between trains entering and leaving the yard, and the train locomotives, and shunting operations. There are generally lines running round the groups of sidings; if this means too long a journey for many locomotives, it can be shortened by diverting the lines for the locomotives under the marshalling hump (Belgium, Finland, Portugal). At Sacavem yard (Portugal) a line is provided at the lead in to the reception group to avoid trains running into this group on the hump side; this access line will eventually be replaced by a loop.

The number of cases of interference can be reduced still further by making a direct connection to about one quarter of the reception sidings, without passing by the hump. The drawbacks of trains possibly getting held up are lessened by making the arrival sidings at least as long as the average train; in this way any train which cannot go immediately to the sidings can stand on this line without blocking the main lines.

Departures from the marshalling group of sidings, on the making up side, only interfer with the latter, which does not cause much inconvenience, as the work is less continuous than the marshalling. However we try not to interfer with the working of several sidings at the same time; with this object the lower group of sidings are either linked up directly with a side line, or equipped with a special departure line between the making up dead ends. If there is not room to site this line between the access lines it is grafted on at the end; this is not such a good arrangement, as it means that a rake cannot be left standing on the shunting line while a train is leaving.

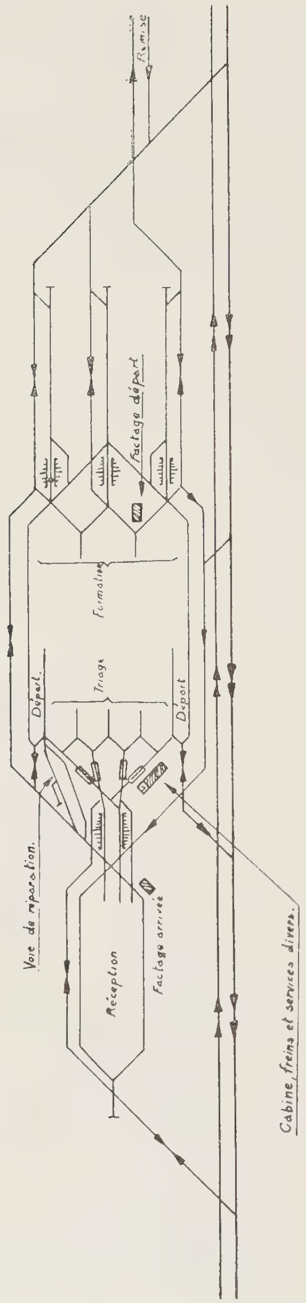


Fig. 1. — *Belgian Railways.* — Diagrammatic plan of a marshalling and making up yard.

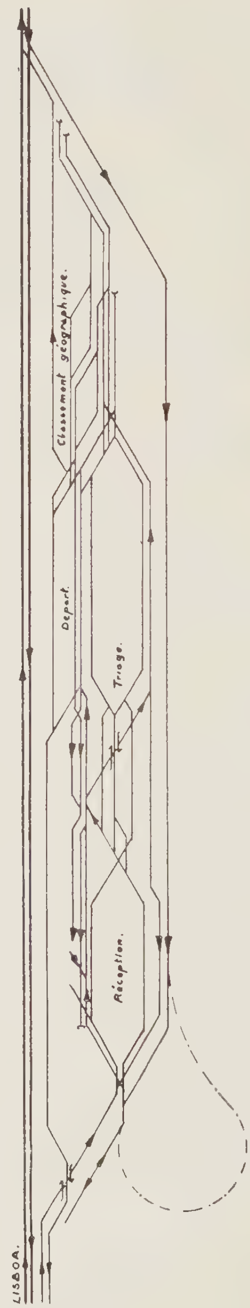


Fig. 2. — *Portuguese Railways.* — Sacavem marshalling yard.

In principle, trains leaving must not be allowed to interfer with the marshalling. When the trains have to leave on the hump side from certain marshalling lines, these must necessarily be the outer lines of the group and are provided with a special departure line. Thanks to the profile that can be given to this line, it is easier for the trains to leave by it than through the end of the group of sidings. Figure 1 shows these different arrangements in diagram form.

To determine the useful length of the sidings, the effective length of the trains must be taken into account, not overlooking the fact that this may be increased in the future, as well as the additional length that may be needed at the ends of the sidings, either for shunting, or so as not to hinder the shunting onto certain sidings which have already got a sufficient number of wagons to form a train, when it has not been possible to draw the latter. For example, these conditions have led to the following lengths : in Belgium, reception 650-750 m (710-826 yards), shunting and forming 700-800 m (765-875 yards); in Portugal reception 550 to 600 m (601-656 yards), shunting 600 to 650 m (656-710 yards), departure 500 m (547 yards).

The number of sidings in each group depends on the analysis of the traffic expected. In the reception sidings, the number of trains and rakes received per siding in 24 hours varies from one yard to another, according to the distribution of the traffic over the 24 hours; an average of 4 trains per siding per day would seem the most usual. The total number of shunting sidings is determined by a graph showing the rate of filling up; in Belgium this generally corresponds to one siding per 60 or so wagons shunted. Out of this total number, only a proportion, corresponding to the number of cuts, are connected to the shunting hump; generally a number is chosen which will give a regular layout of the lead in to the group of sidings, 32, 40 or 48 tracks. In Finland, it is considered that in the most important yards, it is necessary to provide two tracks for each class of train in each direction, so that the work at the hump will not be interrupted when one of the sidings is full of wagons or when the length of the train is completed. In Austria, it is recommended that an additional 25 % be provided in the reception group of sidings and 20 % in the shunting and making up groups, in case any difficulties arise in sending out the trains.

Layout and construction of the groups of sidings.

Two access lines to the main shunting hump are generally provided, to enable continuous shunting to be carried out, using two shunting engines; such lines are also necessary where there are two humps of different height. Hump by-pass lines are in general use; they make it possible to send away trains from the going out end of the marshalling sidings, although this is not often done when there are departure sidings. Austria and Finland make use of two humps of different heights, known as the summer hump and the winter hump; their use, however, does not depend entirely upon the seasons, but also on the climatic conditions each day.

The distance between centres of the tracks in the groups of sidings is 4.50 m (14′ 9 7/16″) to 4.80 m (15′ 9″) (rolling stock gauge 3.15 m = 9′ 15 3/4″); in Portugal it is as much as 5.00 to 5.80 m (16′ 5″ to 19′ 0 1/2″) (wide gauge). From time to time — varying according to the railway — this is increased to leave room for the colour light signals, lighting masts or supports of the overhead wires (up to 6 m [19′ 8 1/4″] in Austria).

The minimum radii allowed are 175 m (574′ 1 3/4″) about the points and crossings, and even 150 m (492′ 1 1/2″) just beyond this area.

In general, there is not any track equipment reserved for the marshalling group of sidings; only in Belgium is use made of special short switches, symmetrical, with the following characteristics; total length 17.856 m (58′ 7″), crossing angle 8° 57′ 1″

(tg 0.157495), radius of curvature 175 m; by using such equipment, a lead-in to a 48 track group of sidings, with two hump lines, is only 272 m (892′ 4 3/4″) long from the top of the hump to the free sidings. The first branch, which is always automatically controlled in Belgium, is at least 30 m (98 5 1/8″) from the top of the hump. In Austria, this distance is reduced to 21 to 27 m (68′ 10 3/4″ to 88′ 7″); it is even proposed to make it 20 to 25 m (65′ 7 3/8″ to 82′ 1/4″) when automatic operation of the equipment is introduced.

The rails used are everywhere the same as the current types on the railway; the ballast, according to the case, consists of cinders, slag, gravel or broken stone. The latter is recommended under the switches at the marshalling lead-in. The yards are drained when necessary.

Longitudinal and cross sections.

None of the Railways who replied have any yards on a continuous slope; the Finnish Railways consider however that such an arrangement has certain advantages.

In yards where shunting locomotives are used, the reception group of sidings is on the level or on a slight slope (2 $^{0}/_{00}$ maximum) towards the hump. In the case of the marshalling groups, a basin shaped profile is generally adopted; in Belgium the slope of these tracks after the points and crossings varies from 1.5 to 2.5 $^{0}/_{00}$ according to the curvature; this leads to a slightly cambered profile. The Austrian Railways intend to adopt a similar arrangement, in order to make up for the greater running resistance on the outer tracks. The departure sidings are generally on the level. Finally raising up the reception sidings or the shunting dead-ends in comparison with the marshalling or making up sidings facilitates bringing up the rakes to the hump.

The average gradients between the top of the hump and the free sidings vary a great deal (7.7 to 16 $^{0}/_{00}$); Fig. 3 gives a certain number of longitudinal sections of marshalling humps. In Austria and Belgium, it is considered best to have a slight gradient, of 2 to 3 $^{0}/_{00}$ beyond the track brakes.

The maximum gradients allowed in the case of train locomotives is 25 $^{0}/_{00}$; in the case of shunting locomotives it may be as much as 60 $^{0}/_{00}$. In the longitudinal section the minimum radius of transitions is 300 and even 200 m (984′ 3″ and even 656′ 2″) in the case of lines that are only run over by shunting engines; they are about 500 m (1 640′ 5″) for train locomotives; these limits are determined by the need to prevent derailments.

Brakes.

Amongst the Railways covered by the present report, only the Austrian Railways use track brakes, using Thyssen jaw type brakes (Frölich) and shoe type brakes made by Büssing; the Belgian Railways are now installing Westinghouse brakes.

These brakes are only used in connection with the marshalling hump, in the first braking zone, to obtain the preliminary braking and spacing braking; in the second zone skids put in position by hand are used; in Belgium these skids are thrown clear by means of deflecting rails 40 m (131′ 2 3/4″) away from the joint of the last switch (end of run braking). On the making up side, nothing but hand placed skid braking is used.

In Austria the shoe type track brakes are each looked after by an employee, whereas the same man is responsible for two Thyssen brakes; in Belgium, a single man is expected to look after all the brakes of a lead-in; in the case of skid put in position by hand, one man is used for each group of 2, 4 or even 6 sidings. The track brake control box is sited on one side of the lead in to the group of sidings, about the middle plane of the brakes.

The arrangements adopted assure satisfactory braking; it is only necessary to use the wagon hand brakes in the case of special transport; in Austria however every group of 6 loaded axles or 10 unloaded axles must have a hand brake.

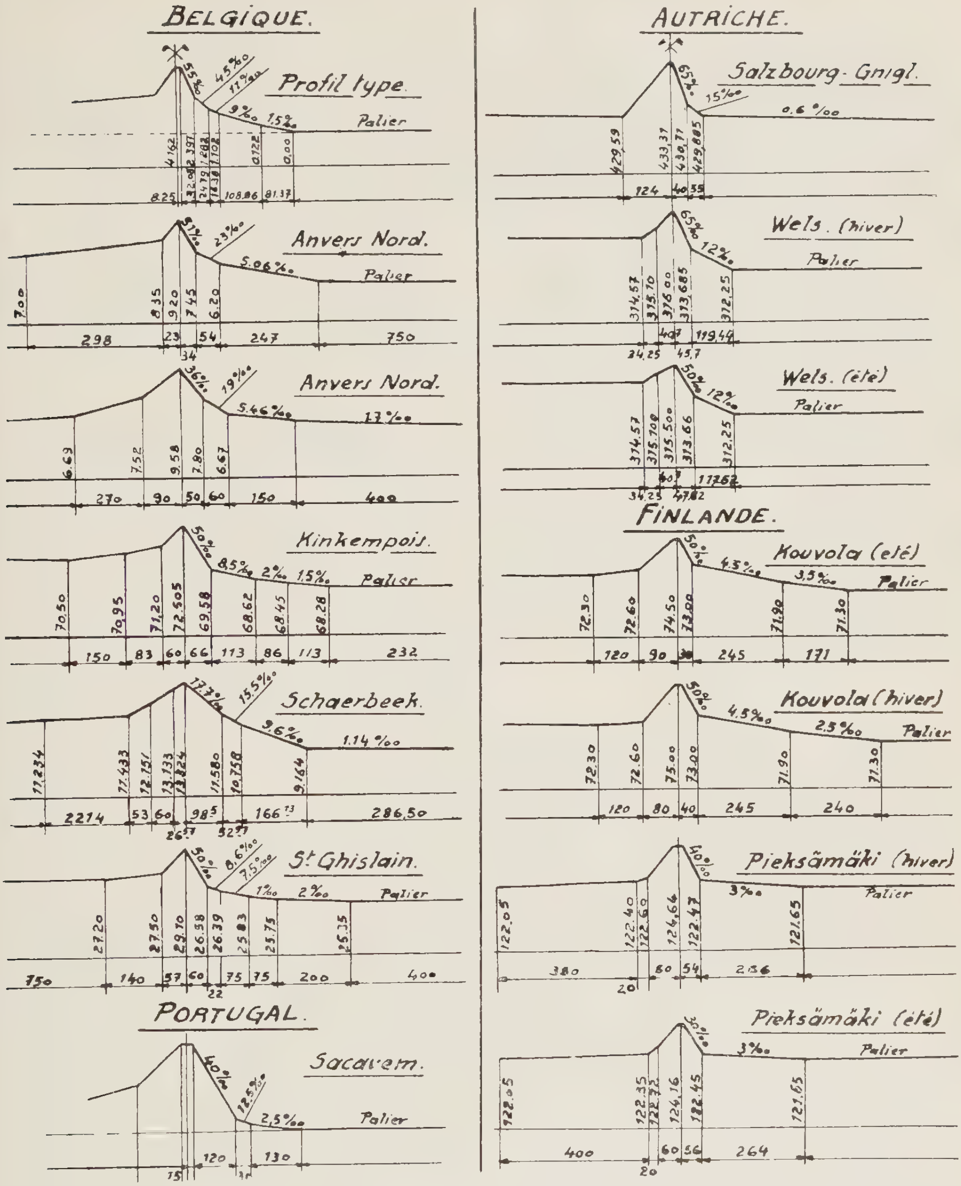


Fig. 3. — Longitudinal profiles of marshalling humps.

BELGIQUE = BELGIUM. — AUTRICHE = AUSTRIA. — FINLANDE = FINLAND.

In the case of the Thyssen (Frölich) brakes used in Austria, the braking effort is limited by the weight of the wagon, plus its load; this effort can be regulated and can be adapted to the type of wagon. Narrow tyres require a strong brake application; greasy wheels lessen its efficiency.

The brakes on order for the first Belgian track brake installation are Westinghouse type 34 brakes, 23 m (75′ 5 1/4″) long. Their power is such that when installed on a gradient of 10 °/°°, they make it possible to slow down a free running wagon, or a rake of a given number of free running wagons from a maximum of 7.30 m (8.30 yards) per second to a maximum of 4 m (4.37 yards) per second; this supposes a maximum weight of 40 t for four wheeled wagons and 68 t for bogie wagons.

The Thyssen brakes are not divided; it may be necessary to install two, one after the other. The Belgian Westinghouse brake consists of two electrically insulated parts, and two parts which can be worked separately; the divisions do not necessarily coincide.

The Thyssen brakes cost 40 000 Reichsmarks in 1940, including the operating gear; the engines also cost 40 000 Reichsmarks. The Belgian installation still being only under consideration it is not possible to give any details about the cost.

Centralised control of the marshalling switches.

Centralised control of the marshalling switches can be either by hand or by motor. When hand operated, it takes 2 to 3 seconds to get the change-over, and 0.8 to 1.5 seconds by motor.

Premature operation of the switches is prevented by providing an insulated rail in front of the points long enough for the point to travel its full course while a wagon is running over the insulated rail. When trains have to be accepted on a marshalling siding in exceptional cases, it is considered sufficient to put the switches out of operation by an elastic system, except in the case of the lead in switch which is put out of work in the same way as points and crossings on the main lines; no special safety precautions are taken during other shunting operations than marshalling. In Belgium, if there is a breakdown in the supply of current, the motors are worked by hand; there is no arrangement to enable them to be worked rapidly by hand. In Austria, standby generators are used, driven by petrol or diesel engines to supply alternating or direct current.

In Austria as in Belgium, in the case of automatic installations, only the lead in switches are automatically controlled. In future Belgian installations, all the branches will be controlled automatically.

Thanks to this system, it is hoped that the employee responsible for operating the brakes will be able to supervise the marshalling; this will do away with two signalmen normally required to operate the points and crossings.

In the old Belgian installations, there was no arrangement for keeping the wagons in their proper order after they had caught one another up. The route taken by a cut is in fact controlled by the previous cut, as the insulated rails are freed. When one cut has caught up with the previous one, marshalling is therefore immediatly stopped. In one installation which has just been put into service, where only the lead-in switches are automatically controlled, there is an electric diagrammatic device to maintain the correct order of cuts following those which have caught up with the previous one. This will also be done in the projected installations, where all the switches will be automatically controlled. This will be achieved by making the cut itself operates the route control; transmission will take place stage by stage by having an insulated rail in front of the cut in question. In addition, at the beginning of the marshalling group there will be a counting system for the cuts, consisting either of an insulated rail or a photo-electric cell. Each time a cut passes the lead-in, a selector moves forward one notch in order to prepare the recording of the destination of the following cut. The route of a cut cannot therefore be affected if two cuts catch each other up in front of it.

The box from which the marshalling is controlled is sited on the side of the lead-in; if track brakes are provided, the box is so sited that the brakesman is in front of the braking areas. On the making up side, each siding is controlled as a general rule

by a box in the lead-in. Its site is selected in such a way that all the switches to be operated are visible. In certain cases where the topography of the site is particularly favourable, two sidings can be controlled by a single box built either on the ground or raised up.

The boxes generally have their floors sufficiently raised up to give good visibility over the marshalling yard, in spite of the presence of wagons on adjoining lines. The windows are made as large as possible, with penthouses to protect them from the sun.

Communications by signals, telephones, loudspeakers, radio, teleprinters, pneumatic tubes, etc.

The yard foreman is in communication with the various parts of the yard by signals, telephones or loud-speakers.

In Belgium, in the new installations, the marshalling yard foreman works in the box from which the switches of the lead-in and the track brakes are operated. The only employees working in the yard are therefore the shunting engine staff, the second line brakesmen, and usually a chief shunter or inspector.

In the case of the shunting sidings, communications are relatively simple. They include :

1) communication between the yard foreman and the shunting engine. This is done by light signals day and night, at the top of the hump and on one or several posts along the reception sidings or the connecting line. Klaxon horns or sirens call attention to any change in the signals.

Two way communication by radio between the yard foreman and the drivers of the shunting engines is under trial at Schaerbeek yard.

2) communications between the yard foreman, the inspector out in the yard and the second line brakesmen. This takes place by means of an installation using bells, microphones and loud-speakers. Two way communication is also provided between the brakesmen and the man at the hump.

The making up yard foreman usually works out in the yard. Communication by microphone and loud-speakers enable him to get in touch with the train signal box, the boxes from which the points and crossings of the making-up group of sidings are operated, and the shunting foreman. Communication between the yard foreman and the shunting locomotive is by means of light signals and klaxon horns. In certain cases a siren has been installed in the middle of the sidings, to give a stop signal to the locomotive when the rake it is pushing goes too far and is in danger of fouling the switches on the other lead in to the sidings.

The central control box (regulator) is linked up by telephone with the yard foremen and the signal boxes. There is no point in the shunting foremen, pointsmen, inspectors and shunting locomotives being able to communicate with each other, as the yard foreman is responsible for their work.

Telephone communications should in principle be made through a central automatic exchange.

In Belgium, in important marshalling yards, the regulator is equipped with special dispatching apparatus. This installation is altogether identical to that of a line dispatching installation; the man in charge of the marshalling is listening in all the time on a special circuit known as the regulating circuit. All the signal boxes of the yard and its neighbourhood are linked up with this circuit as well as the different yard foremen, foreman's depot, locomotive shed, and various accessory services.

Only Austria mentions the use of pneumatic installations to carry the waybills; on other Railways, this is still done by courrier; it is generally recognised however that some mechanical arrangement would be extremely useful.

Below we give certain details about the equipment used in Belgium with their bell system and radio installations.

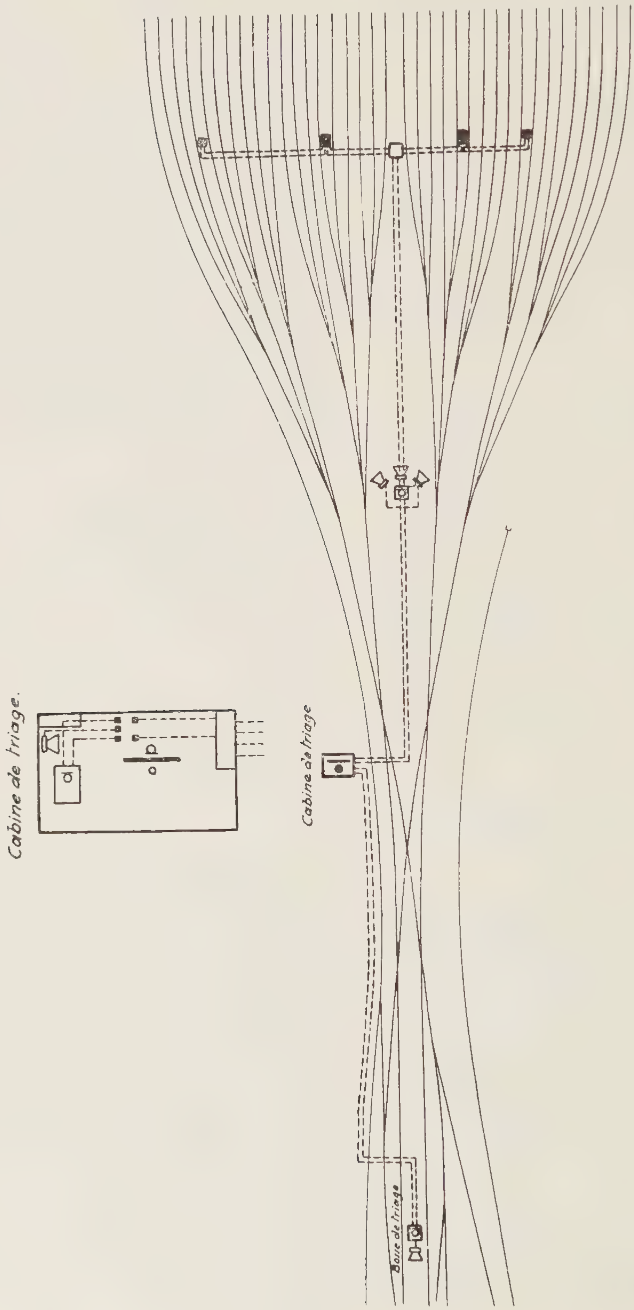


Fig. 4. — *Antwerp North.* — Loud speaker equipement.

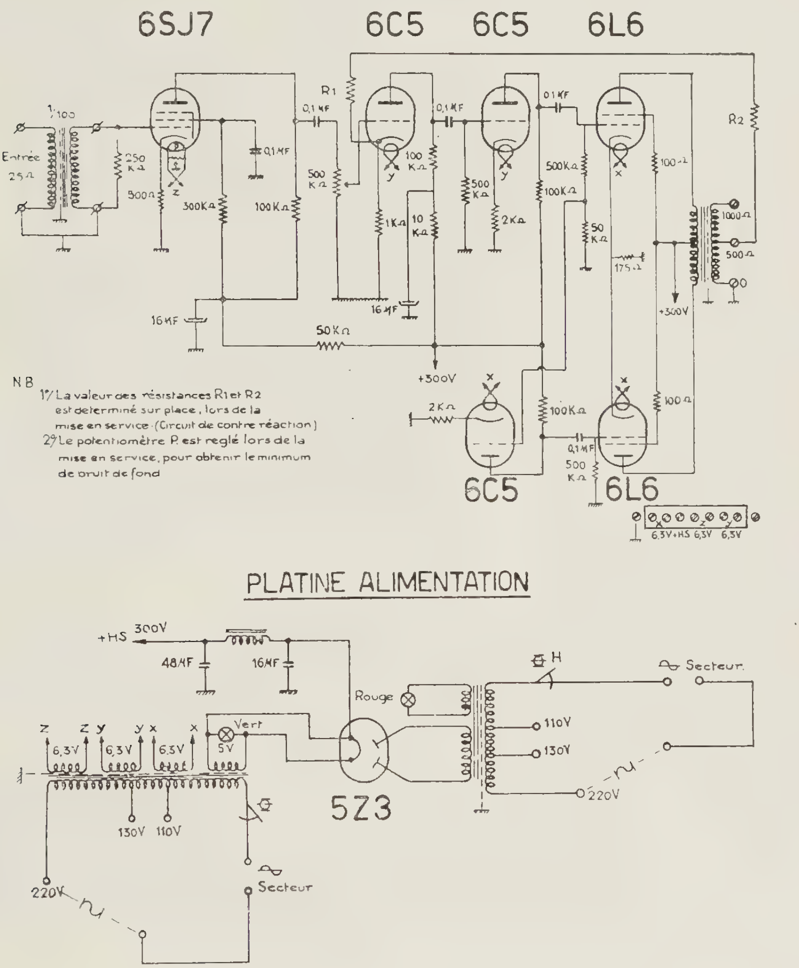
Bosse de triage. = Marshalling hump. — Cabine de triage. = Marshalling box.

Bell systems.

Figure 4 shows part of a plan giving the arrangement of microphones and loudspeakers in a marshalling yard. Figure 5 gives a diagram of an amplifier.

The output power of the amplifier used is 15, 25 or 50 watts according to the

AMPLIFIER PANEL



FEED PANEL

Fig. 5. — Amplifier — 15 Watts-standard.

N. B. — 1) The value of the resistances R1 and R2 is determined on site, when the equipment is put into service. (Counter reaction circuit.)
2) The potentiometer P is regulated when put into service, to obtain the minimum of background noise.

number of loud-speakers to be operated simultaneously. The distortion is less than 3 % at the power indicated.

The amplifiers are fitted with an automatic volume regulator, intended to make the amplification of the sound as independent as possible of the tone of voice in which the announcement was made into the microphone.

The amplifiers have a lineal answering curve between 50 and 10 000 HZ at ± 3 decibels. Tone control makes it possible to lessen serious frequencies below 300 HZ. The background noise must be at least 50 decibels lower than the nominal output level.

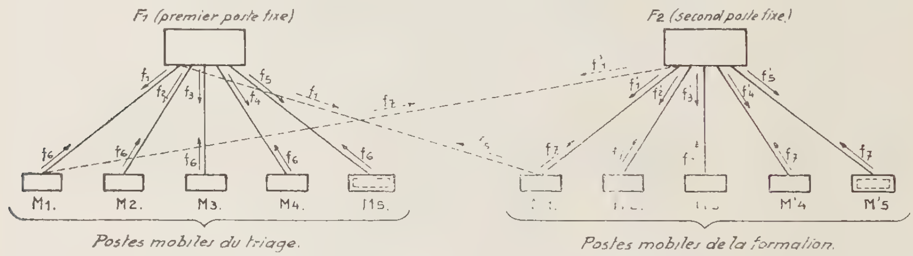
The electronic valves are only under high tension while the announcement is being made. The microphones are of the electro-dynamic type, the loud-speakers have a 25 watt compression chamber; their cutout frequency is less than or equal to 250 HZ. The cables used with the microphones are specially lined to prevent magnetic and electrostatic induction. The loud-speaker cables are of the ordinary telephone type.

Radio communications.

The radio equipment under trial in Belgium is of the two way type. The fixed post is in the marshalling box; the moveable posts are on the shunting locomotives.

The installation now under trial works on a single frequency (80.5 MHZ). This has one drawback : as the different locomotives used in the marshalling yard pick up all the announcements including those which do not concern them, there is no doubt but that the attention of the driver is distracted and they may overlook an order to stop that does concern them.

Consequently in the installations that will shortly be put on trial, there will be a different frequency for each locomotive. In a station where radio is to be installed in two separate yards, for example the marshalling and the making-up yards, the frequencies will be divided up as shown in Figure 6. The frequencies that will be used on the locomotives have not yet been definitely decided by the department concerned of the Telephone and Telegraph



Connections between F_1 and F_2 and all the mobile posts.

f_1 157.50	f'_1 158.34
f_2 157.62	f'_2 158.46
f_3 157.74	f'_3 158.58
f_4 157.86	f'_4 158.70
f_5 157.98	f'_5 158.82
f_6 158.10	f_6 158.10
f_7 158.22	f_7 158.22

——— – ➤ frequency of emission.

Fig. 6. — Distribution of the frequencies (final scheme).

N. B. — F1 (premier poste fixe). = (First fixed post) — F2 (second poste fixe). = (Second fixed post).
Postes mobiles du triage. = Mobile marshalling posts. — Postes mobiles de la formation. = Mobile formation posts.

Services, but they are likely to lie in the 157 to 162 MHZ range.

Figure 7 shows PYE equipment under trial at Schaerbeek making up yard (frequency 80.5 MHZ). These posts are fed by turbo-alternators of 24 volts 1 000 periods.

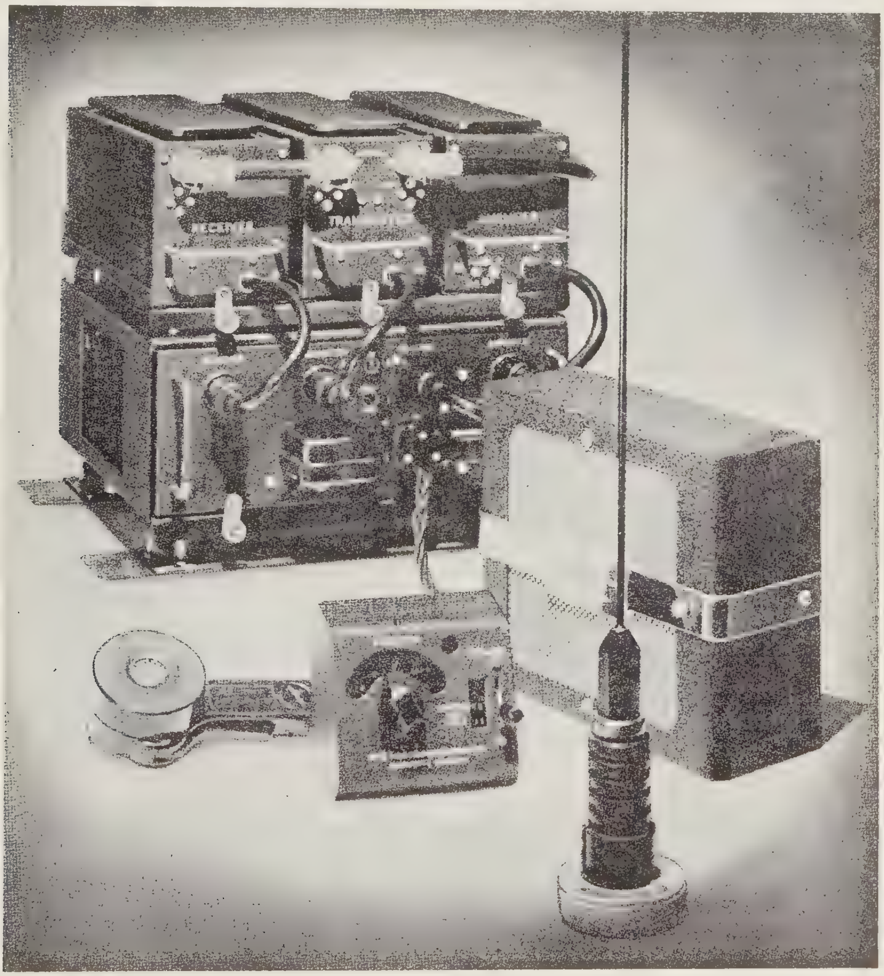


Fig. 7

Figure 8 shows a mobile post on a shunting locomotive; Figure 9 the fixed post in a signal box.

Various troubles were experienced when the installation was first put on trial, due in particular to a lack of regularity in the supply current from the turbo-alternator and the lack of strength of the equipment. The equipment on the locomotives was in fact based on that used in motorcars, and did not take into account operating conditions on a locomotive (shocks, coal dust, dampness, temperature).

The apparatus which will shortly be put on trial are of American construction (Bendix). The frequency can be modulated. The supply current at the fixed post will be 50 watts, and that of the mobile posts 15 to 20 watts. The mobile posts will be fed by a turbo-dynamo supplying 500 watts under a tension of 24 volts d. c.

In Spain trials of two way communication by radio have been made with two types of equipment :

1) by frequency modulations and wave lengths of about 7 m, fed from the railway supply or batteries : 110 volts, 6 v;

2) by so called « Walkie-Talkie » equipment, or receiving and transmitting batteries with minature valves, assembled together in the same micro-telephone. The wave length used with such equipment is about 50 m.

Fig. 8

Lighting.

The lighting at ground level must be good enough for the waybills to be read and the tickets on the wagons, as well as to enable any obstacles between the tracks to be observed.

In Austria 12 m (39.37 ft.) masts projecting a penetrating cone of light have given good results. At Salzbourg-Gnigl, there is also a mast with 8 floodlights.

In Finland, in the most important marshalling yards, high posts or columns with oblique lighting are used. In average sized yards, electric lamps are used. No special arrangements are made when it is foggy, except that sometimes the signal lights are reinforced.

In Lorenzo-Marques yard, groups of floodlights giving oblique lighting are provided.

In Belgium, in nearly all the area between the hump and the end of the second braking zone, the practice is to have a minimum lighting of 0.7 lux on the horizontal plane. This is usually obtained by the use of lamps on posts, evenly distributed throughout the area, the lighting on the most favourable level not being much greater than that obtained on the horizontal plane. In the groups of sidings, the posts carrying the lamps are some distance apart, so that the minimum lighting in the intermediate areas may be as low as 0.1 lux.

The two conditions that have been sought after in recent lighting installations are :

a) to make obstacles and moving objects visible between the poorly lit vertical faces and the strongly lit horizontal plane;

b) prevent any possibility of dazzle by diffusing the light through deep reflectors.

The installation which best meets these desiderata is that consisting of multiple lighting points, placed as high as possible (11 m [36 ft.] or higher), the light from which falls as vertically as possible. This arrangement also gives the best results in foggy weather. It has the drawback of taking up space in the sidings because of the many lighting masts. Consequently it has been decided, in agreement with the Operating Department which wishes to make the lead in to the groups of sidings very close together, to use flood-lighting. The first such installation will be carried out at Courtrai.

Austria reports the use of mercury-vapour lamps.

In Spain, it is considered that the minimum lighting should be :

9 lux in the busy lead in areas,

3 lux in the groups of sidings.

Floodlighting groups on towers about 25 m (82 ft.) high are used, with oblique lighting compared with the direction of the traffic.

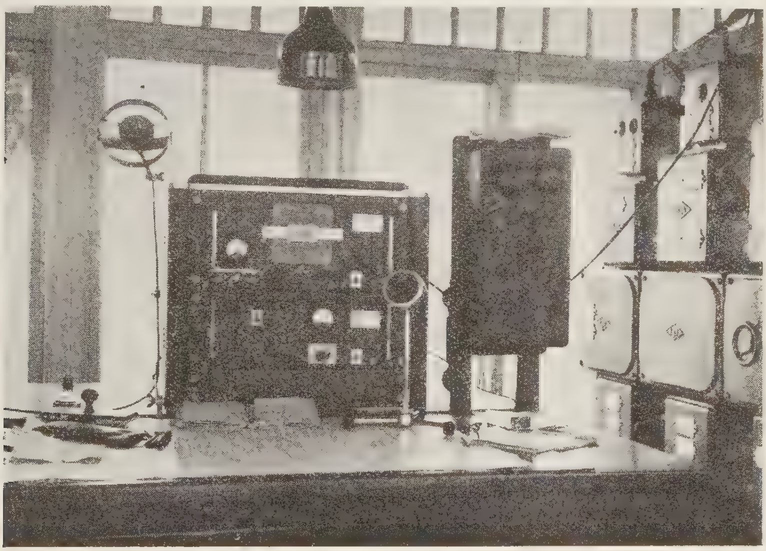


Fig. 9

Buildings.

In addition to the signal boxes, the buildings required are offices on both the arrival and departure sides, rooms for the staff — cloakrooms, canteens, dormitories — stores, a main building containing the marshalling box, the place from which the track brakes are operated, various offices, etc.

All the Railways group the buildings together as much as possible, and site the main building in the centre of gravity of the yard, i. e. near the marshalling hump and track brakes.

[385 .1]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

15th. SESSION (ROME, 1950).

QUESTION X.

Drawing up the financial balances regarding passenger and goods services taking into account the prime cost of trains : per category, per line and per type of motive power. Principles and methods of calculation.

REPORT

(America (North and South), Burma, China, Denmark, Egypt, Finland, Great Britain and North Ireland, Dominions, Protectorates and Colonies, India, Iran, Iraq, Malay States, Norway, Pakistan and Sweden),

by Arne Sjöberg, M. A.,

Chief Research Economist, Swedish State Railways.

CONTENTS.

I. INTRODUCTION.

As in manufacturing and marketing, one is trying since a long time to develop methods to determine the relative profitability of the various branches of railway production. Although the production of an enterprise as a whole shows a profit, certain branches of production may be unprofitable, so that, if production in these branches was reduced or withdrawn, the total profit of the enterprise would increase. The administration of a railway enterprise must, of course, try to discover such unprofitable branches of production, in order to be able to take effective measures, with a view to improve the business economy, e. g. by raising the tariffs, reducing or entirely or partially withdrawing the branch in question. Often the cause of such unprofitable branches of business is — to cite an American distribution cost expert — that the management follows a laissez-faire attitude in regard to the direction of marketing effort.

The result may be a disproportionate allocation of efforts in relation to the potentialities of various branches of market of the enterprise, so that much effort, and therefore many expenses, has to be spent in order to bring in only a fraction of the sales volume.

As an example of such an unfavourable relation between expenses and revenues of a certain fraction of the sales volume it may be said that, when the Swedish State Railways in 1933 examined the composition of their parcels goods (LCL) traffic, it turned out that the number of shipments of 30, respectively 60 kg of maximal weight was not less than 40.2, respectively 63.5 % of the total number of shipments, while the weight, and in consequence the revenues, of such small shipments was only 9.1, respectively 20.4 % of the total revenues of the parcels goods traffic. In consequence of that a simplified way of handling and billing such small shipments was adopted. This made possible certain savings in operating expenses. Moreover some years ago the tariffs for such small shipments were increased relatively more than for the rest of the freight traffic. By means of these two measures the relative profitability of this fraction of the freight traffic was considerably improved.

Management can often reduce costs and increase profits by abandoning a laissez-faire or complete-coverage policy as regards the direction of marketing effort, replacingit by a policy of directing or confining marketing efforts as much as possible to profitable customers, order sizes, sales territories, commodity lines, etc., a policy which is often called selective selling.

Unprofitable branches of the railway traffic can be localized by cost and revenue analysis, and railway management is then in a position to decide if and in what way the losses of these branches can be reduced and possibly turned into profit. In the railway industry such cost and revenue analysis in order to determine the relative profitability of various branches of railway traffic was started nearly as early as the railways themselves. Two such calculations occur, for instance, in a study of 1836 by the Austrian engineer Franz Anton von Gernstner, concerning the first railway in Russia between St. Petersburg and Zarskoje-Selo. Here v. Gerstner endeavours to determine « the proportion between the net-revenues from the passenger traffic and the net-revenues from the goods traffic » On basis of specified accounting data concerning costs and revenues during certain years of the English Liverpool-Manchester Railway and the French Lyon-St. Etiennes Railway v. Gerstner gets an operation ratio (proportion in per cent of railway operating expenses to railway operating revenues) of passenger traffic and goods traffic of 46.6 %, respectively 64.8 % for the Liverpool-Manchester Railway, and of 58.6 %, respectively 75.5 % for the Lyon-St. Etiennes Railway. Then v. Gerstner uses this statement about the relative profitability of passenger and goods traffic for his prognosis about the probable result of the Russian Railway project.

Calculations like v. Gerstner's that were meant to make clear the question about « the proportion between the net-revenues of the passenger traffic and those of the goods traffic » were later on applied to different railway enterprises over the whole world, to various extents and according to different methods, either as a routine from year to year, or only as special investigations on certain occasions. The interest in such calculations as for cost analysis and cost control on the part of the railway managements has been varying with the economic state of affairs, and has always been most intense in times of small traffic volume.

The present situation as regards these « profit and loss statements » of passenger and freight service is made clear by the answers from various administrations consulted. It is interesting to note that only a few of the railways in the countries concerned (Scandinavian countries, Great Britain, British Commonwealth, U. S. A. and other English speaking countries) make such statements. Annual statistical statements, showing the estimated profit or loss

on the working of passenger and freight service, are prepared only by a minority (about 10 %) of the railways concerned viz. Norwegian State Railways and South African Railways. Earlier the Swedish State Railways and the Indian Railways prepared such annual statements too, but this compilation has now been suspended in expectation of other more accurate methods of calculation.

Most of the other administrations consulted gave information that they do not prepare such profit and loss statements on a yearly basis, but that on special occasions studies are made to determine the economic results of particular services — freight, passenger or other services — and of special lines of the railway system.

As to the reasons for the introduction of such profit and loss statements of various classes of traffic, it seems that most administrations originally evolved them for the purpose of supplying information, considered to be of value as a guide for fixing the general level of rates and fares and for controlling the general efficiency of operation in the different classes of traffic, etc. The importance of these statements seems, however, as time went on, to have changed from the final results about profits and losses to the cost and revenue analysis, implied in the preparing of these statements, and many administrations nowadays use them primarily as a basis for conducting special inquiries into various phases of railway working (efficiency analysis). Often the profit and loss statements are also used as a general indicator, facilitating the determination whether further studies should be made or not, concerning e. g. applications for partial or entire abandonment of operations on certain sections of lines, withdrawal of certain trains and other measures for achieving economy in operation.

II. — Some special features of railway production and pricing.

The production of the railways is composed of transport services, intending to convey passengers, goods, etc., between various points of the railway system. The number of the single transportation acts in the passenger and goods traffic that a railway performs during one year, is immensely great. The cost conditions of the different transportation acts or types of transportation acts are generally very different. Fixing the tariffs, it is, in general, not practically possible to pay perfect regard to such differences in costs between different transportation acts, but the same tariffs are used for transportation acts that are similar in some degree as to costs. This tariff system for different types of transportation acts becomes, however, highly schematic, and the same tariff can therefore often be applied to transportation acts differing considerably as to costs.

Railways are thus multiple product establishments which are used for simultaneous production of many kinds of services. As with all such multiple product production, there arises in cost calculations of different products or production branches the problem of *common* or *joint costs*, i. e. costs incurred in common, by two or more services. Costs incurred by a special service may be termed *separable costs*.

In railway operation with its heavy investments in way, structures and equipment there is, of course, moreover the problem of *constant (fixed) costs*, i. e. costs which within the variation of output under study are unaffected by increases or decreases in production. Costs that are affected within the variation of output under study, are called *variable costs*.

Neither common nor constant costs can as a rule be separated between the commonly produced services in any economically relevant way, as these costs are incurred on behalf of the production as a whole. In practice there occurs, however, a distribution of these common and constant costs, especially in enterprises or industry branches with a monopolistic position in the market. These « full costs » of various products, received by distribution of common and constant costs, are often used for e. g. valuation of stores and fixing of prices, especially by enterprises that use « cost-

plus »—pricing. Yet it may be said that both political economists and modern business economists agree that an economically adequate allocation of these costs is only possible in exceptional cases. It is therefore generally not possible to form some economically adequate allocation scheme of these costs between various products or production branches. Fortunately it is not necessary to determine the full costs in order to be able to perform a rational production and price policy. On the other hand, to make possible such a business policy it is, however, necessary to know the additional and subtractional costs which will arise by variations in the amount of production as to various products or production branches (cf. part III).

The general financial accounting does not specify the costs of different products or different classes of production. According to this the costs are categorized into service branches, e. g. traffic service and engine service and for each service branch into personnel and material costs. On the other hand, this financial accounting explains nothing about the costs of different products or classes of products. In order to get such information, one has to perform special investigations, corresponding to the calculation of total costs and costs per item in various spheres of production, now commonly used in industrial cost accounting. Such a specification of expenses of a past year between different products or classes of products has been used since a long time by various railway managements. In the beginning the specification was confined to the costs of passenger, respectively goods traffic. Later on these specified annual costs of passenger and goods traffic were compared with corresponding annual revenues, and then one was able to calculate surplus and deficit for the class of traffic in question. Since the accounting systems of the railways became more detailed, these calculations too were developed in several respects, taking into account different sub-branches of passenger and goods traffic and also different lines of the railway system.

The value of such calculations, without any specific question or problem as a basis, must, however, be regarded as rather small. In an enterprise with as complicated production conditions as a railway it is necessary to put well-defined questions as regards all cost calculations, if these should be useful for practical action. First with a well-defined acting alternative as a basis it will be possible to get a definition of the costs and revenues of a certain actual acting alternative. Of interest in such calculations is not an allocation of the total annual costs between various products or classes of products, but an estimation of the separable costs of different products or classes of products.

III. — A general approach to economic calculations of use for guiding enterprise activities of a railway.

During the last decenniums the business problems of the railways have become more complex and difficult than before above all owing to the fact that the monopolistic position of the railways in the sphere of land transport was gradually weakened by the fast development of the motor traffic during this period. The earlier, relatively quiet, development of the railways during their time of monopoly was followed by a more dynamic development, where the railways, in an intense competition with other forms of transportation, had to fight for their traffic. The railway enterprises must, therefore, more than before, have at their disposal reliable and sufficiently detailed calculations about costs and revenues of different products or classes of traffic etc. Profitability and cost calculations are as necessary for guiding the economy of a railway as modern signaling systems are for safety in train operating. Without sufficient knowledge of costs and revenues of different products, etc., one does not know how to act in an economically rational way. In manufacturing industries one has been conscious, since several decenniums, of the necessity of sufficient cost information as a basis for all important measures of business policy. Also the railways are now more interested than before in what is called by a collective term « top

management » and « scientific management », in which production planning and control including cost analysis, flexible budgeting and standard costs, work simplification and other means of control and reduction of costs constitute important elements.

An active business policy is based on more or less detailed plans for the future, and the choices as to acting alternatives (business plans), made by the administration of the enterprise at different dates, are determined by calculations or imaginations about the influence of the acting alternative in question on the future expenses and revenues of the enterprise.

The situations that the administration of the enterprise is confronted with, if investments, tariffs, train schedules etc., are concerned, and for which the enterprise in its activity needs guiding by economic calculations, are so varying, so heterogeneous, with regard to the different acting alternatives between which the managemenr can choose, that the calculations in their turn become very varying, in order to give expression to what is economically important in the various situations. Since every business policy is a choosing between different acting alternatives, the more detailed shape of the calculations depends in every single case wholly on the acting alternatives between which one can choose in a given situation. The acting alternatives themselves demand, in order to be defined, a thorough analysis of the economic situation of the enterprise. Only by defining the calculation situation itself and the alternatives open to choise by the enterprise, one can get a clearly defined conception of the costs. These will then be defined with regard to the acting alternatives between which a choice can be made. The costs and revenues will then express the economic consequences of choosing a certain alternative. Every calculation is, therefore, a comparison between different ways of acting in a certain situation.

Thus the shaping of the business policy of a railway enterprise, both with regard to investments in way and structures, locomotives and other rolling stock, employment of personnel, and current production policy as concerns quality in seervice, etc., requires a sufficient knowledge of the structure of the railway traffic, and of tendencies of traffic development by applying lower or higher tariff prices, as well as a thorough knowledge of the production and cost conditions of the railway enterprise. In the present economic situation of the railways, with an intense competition from other means of transportation, the question is to manage the available resources (men, equipment, etc.) in such a way that a relation as favourable as possible is achieved between revenues and costs of the railway. Although the final judgment and decision as to different investments, price-political measures, etc., does not always take place in practice only according to business-economical principles, but often also with regard to the influences of the measures in question on the social economy, these decisions are facilitated if the business-economical consequences of the different alternatives have been made clear in advance.

Common for all such *profitability estimations* that the railway enterprise needs for its business policy is, that they try to estimate, what *changes* can be expected to be caused by a certain measure (business plan) as to the amount and the temporal distribution of the *future* expenses and revenues of the enterprise, in comparison with the case, that the plan in question is not realized or that a certain other plan is chosen. By such calculations the net-value as well as the relative value for the enterprise of each of the relevant business plans can be stated.

Here it may be stressed, that only expenses and revenues expected in the future are included in these profitability calculations. Economic events before the calculation date can only mediately be relevant for the calculation, i. e. by influencing the enterprise's expectations and judgment of the future. The past revenues as well as the past expenses of purchase of assets still in use or the values of these assets according to financial accounting at the date of the calculation are without significance for the calculations mentioned here.

Characteristic of these profit calculations is the fact that they give an answer to the question, what *changes* are likely to happen in the expenses, revenues and net-revenues of the enterprise, if a *certain change* is made in e. g. operation plans, investment plans, price policy. The terms relevant for these calculations are thus *additional (incremental) and subtractional (decremental) expenses and revenues.*

By formulating the calculation problem in this way, one escapes the cost and revenue allocations, questionable in many cases, which are characteristic to a high degree of traditional cost accounting. As the object of the calculation in every case is a special business plan, all differences in costs and revenues between rival alternatives will become *separable* (additional, subtractional) costs and revenues to the plan under study and no common or constant costs or revenues need to be allocated.

It might be evident by what is mentioned above that there exist no differences, as to the formulation of the problem or the general calculation outlining, between profitability calculations referring to price-fixing and other forms of sales policy; choice of productive resources, production organisation and management efficiency control of selling and production activities. In all these calculations it is tried to estimate what changes will occur in the expenses, revenues and net-revenues of the enterprise if a certain change is made in the business plans.

IV. — Calculations of net railway operating income from passenger and freight service (surplus and deficit calculations).

The surplus and deficit calculations for different traffic branches, lines, etc., performed by the railway administrations, were drawn according to two different points of view, i. e. *firstly* in the form of a *retrospective* analysis of the expenses of a past year, *the accounting method*, *secondly* in the form of a *prospective* estimation of how the future expenses and revenues of the enterprise might be influenced by a certain way of acting, *the alternative budget method.* This method was discussed, under the term of « profitability estimation », in part III.

As to the accounting method, one can distinguish two lines of development, *firstly* one more schematic that is mainly confined to separating the expenses between passenger and freight traffic only, *secondly* a more detailed accounting analysis, according to which a minute division of the expenses between various traffic branches, and in each traffic branch between various production spheres, takes place. The aim of the last mentioned, more detailed form of the accounting method is to show the allocated costs of different production spheres and, by comparing these costs with the number of service units produced in the spheres in question, to make possible a calculation of the costs per unit of the different services or products. This more detailed accounting method, which corresponds to the calculations common in manufacturing industry, has been applied in its most pronounced form by the German State Railways and in a modified form by e. g. American and Scandinavian Railways.

The accounting method in its usual formulation may be summarily characterized in the following way [1] :

« By the accounting method is meant the system which grows out of taking the individual entries of cost (originally gathered for purpose of the income account and the balance sheet) and charging them against particular items of product. Some can be charged directly, because the materials or services they represent are physically identified with some unit of product in a visible and unmistakable fashion. This is not always quite the same as saying that these expenses are economically caused by these items of product, ... , but it is an evidence of one kind of causation and it is the kind which the methods of account-

(1) J. M. CLARK : The economies of overhead costs, Chicago 1923, p. 216-7.

ing are capable of recording. When it comes to expenses which cannot be identified with units of product in this direct fashion, accounting tends to do the thing most nearly similar — which may or may not be the next best thing — and allocates these « indirect expenses » to one or the other department, process, or commodity on some predetermined basis. Either of these methods retains one dominant characteristic of the system of general accounting of which they are an offshot. Costs are built up by a process of arithmetical addition, and the whole is equal to the sum of its parts. »

However, the accounting method will very seldom and very imperfectly indicate the additional or subtractional costs of added or subtracted traffic, which costs, as mentioned before, are the only ones, in a narrow sense, that are relevant from a business economical point of view. « Nevertheless the uses of the accounting system are obvious and quite indispensable. It tells management how its costs are behaving, and if there is a suspicious increase in the costs, which may be a symptom of a loss of efficiency somewhere, the management has the figures recorded in sufficient detail to make it possible to tell in what department the increase occured, whether it was in materials or labour, and in what step of the process it occurred, or whose machine it was which took an unusual amount of time in the completion of a given job. »

« The management is accustomed to guide its financial and technical policies according to its costs, among other things, and whatever method it uses, right or wrong, logical or illogical, have at least stood the test of experience; and in any case, a knowledge of what has actually happened is the necessary basis for all intelligent judgement. However, this will not of itself tell the manager what his costs will be next week or next month if he follows a given policy, and for many purposes he needs to be able to prophesy in this fashion. This the accounts, taken by themselves, will not enable him to do» (1)

(1) J. M. Clark : ibid., p. 222.

V. — The accounting method.

Profit and loss statements of passenger and freight service have often been prepared currently from year to year according to the accounting method in different countries.

Thus, in U. S. A. annual statements of the economic results of passenger and freight traffic are prepared by the Interstate Commerce Commission on basis of informations supplied by the different class I railroads as regards the separation of their expenses between passenger and freight traffic. Similar profit and loss statements are also made by the South African Railways and the Norwegian Railways. Also in Sweden such accounts of the economic results of various traffic branches in the passenger and freight traffic were made during the 1930-ies. Moreover, monthly accounts were made of the direct expenses of each traffic branch and the corresponding revenues. In Germany too such accounts of the passenger and freight traffic were prepared, first quarterly and then annually.

In U. S. A. the allocation of operating expenses between passenger and freight service according to a certain formula was earliest prescribed to the railways by the Interstate Commerce Commission in 1888. This rule, however, was abandoned in 1893 on the ground that no trustworthy rule was believed to exist for making the separation of expenses and because the results were rarely used. A new revised scheme for the allocation of operating expenses between passenger and freight service was not issued by the Commission until 1915. In revising the new scheme the commission was helped by a special committee of railway officers, but these officers did not depart from the position they had previously taken, « that no uniform base could be adopted which would apply equitably under all conditions ». As this new scheme which, with some alterations, is still valid for the railways in U. S. A., may have had some influence on the formulation of similar schemes in other countries, it might be of interest to give an account of the main features of this plan of 1915. A

historical survey of the different methods that have been developed in U. S. A. up to the year 1922 to ascertain the net operating income of transporting passengers and freight by railway have been given by Mr. Harrison (1) and Mr. Dunn (2), American reporters upon the question of « Net costs, Rates », to the Ninth Congress of this Association, which should have been held in Berlin in 1915, but was later held in Rome in 1922.

In his report Mr. Dunn gives an account of the preparatory work for the scheme, stated in 1915 by the Interstate Commerce Commission, for separation of expenses between the two classes of traffic and his report also quotes a very concise and instructive summary of this new scheme, which reads as follows (italics supplied):

« Briefly, the Commission, while avoiding extreme particularity in its instructions, lays down the general principles that :

1° Such expenditures as may be definitely and accurately allocated should be reported separately;

2° Such expenditures as may not be definitely and accurately allocated, but which are susceptible of apportionment on some basis which will approximately represent the facts, should be pro-rated;

3° Such expenditures as those which defy any accurate or even any approximate allocation or apportionment should be reported as « undivided » the Commission to determine later, or as needed in special cases, how the undivided items should be split between the two classes of service.

The three divisions, then, are :

a) Direct charges;

b) Indirect charges susceptible of approximate separation;

c) Overhead or other joint costs which are very difficult to separate.

In the *first group* are the wages of the locomotive and train crews, the cost of locomotive fuel, the maintenance of motive power and other rolling stock, the charges for freight claims and baggage claims, and other minor items of expense which may be kept entirely distinct by classes of service.

In the *second group* are such accounts as station service, which may be directly allocated in a large part, the remainder to be divided in proportion to « man hours » in each class of service; yard service, directly allocable in part, the remainder to be separated in proportion to « locomotive hours » in each class of service.

In the *third group* are most of the items under maintenance of way and structures, such as roadway maintenance, the renewals of rails, ties and ballast, and the maintenance of work equipment. It includes as well all items classified as general expenses.

Throughout the *maintenance of way group*, which presents the most difficult problems in apportionment, the Commission requires that under each account such expenses as may be directly traced or recorded should be charged either to the freight or to the passenger service, the remainder to be regarded as joint expenses and reported as undivided. Superintendence, for example, is to be reported as undivided. With respect to maintenance of station buildings, the rules require that carriers keep a record of maintenance costs of freight stations (to be charged to freight) and of passenger stations (to be charged to passenger) and that the remainder should be pro-rated in the same proportion as the direct charges to that account. All roadway and track expenses, with the exception of yard track maintenance (which is to be recorded separately and divided between freight and passenger in proportion to switch locomotive miles in each class of service) and maintenance of roadway buildings, are to be reported as undivided. Maintenance of water and fuel stations is to be divided on the basis of the freight and passenger proportions of fuel costs. Maintenance of shops and engine houses is to be divided in the proportion which the freight and passenger

(1) *Bulletin of the Railway Congress Ass.*, 1914, p. 857 ff.

(2) *Bulletin of the Railway Congress Ass.*, 1922, p. 123 ff.

services assume in the total charges to the maintenance of equipment group of expenses. The cost of maintaining grain elevators, storage warehouses, and the like, is to be assigned directly or apportioned according to the facts in individual instances. The maintenance cost of telegraph and telephone lines, and of signals and interlockers, is to be divided on the basis of transportation train miles. Power plant maintenance is to be assigned according to facts in individual instances. Maintenance cost of paving roadway, machines, etc., and the charges to injuries to persons, insurance, stationary and printing and other maintenance of way expenses are to be reported as undivided, unless a determination of facts in individual instances makes definite allocation possible. The cost of maintaining joint tracks and other joint facilities should, as far as practicable, be treated individually according to the use made of them by the reporting carrier, regardless of the use made of them by other carriers.

Under *maintenance of equipment* expenses one item only (work equipment-repairs, depreciation and retirements) is to be reported as undivided. The maintenance of work equipment is to be regarded as an undivided expense and should be treated in the same manner as roadway and track costs. With respect to the maintenance and replacement of locomotives and cars (other than work equipment) the railroads are required to keep their accounts in such form that the actual cost of repairing and replacing of freight locomotives and cars shall be charged to the freight service, and that the similar costs for passenger locomotives and cars shall be charged to the passenger service. In the case of locomotives used in both classes of service, the expense is to be pro-rated on the basis of locomotive miles in each class of service, although permission is given to use « some arbitrary deemed by the carrier to be applicable, as for example, by making one and a half passenger locomotive miles equivalent to one freight locomotive mile ». The cost of maintaining locomotives used in mixed train service is to be apportioned on the basis of car miles in mixed trains (unless the carrier is able to make a more nearly accurate estimate), and the maintenance cost of switch locomotives is to be divided according to the freight and passenger switching locomotive miles. For the latter account the railroads are permitted to take all yards together annually. This is essentially a « locomotive hour » basis, since switching locomotive mileage is computed on the arbitrary basis of six miles per hour, according to the rules of the Commission pertaining to the compilation of locomotive, train and car mileage.

For the charges on account of *depreciation* and retirements of locomotives and cars the rules require an assignment « direct as far as practicable », and an apportionment of the unassigned remainder « according to the mileage made in each class of service by the individual locomotives (or cars) or by classes of locomotives (or cars) ». In the case of locomotives alone « if this method is not practicable, than the division should be made according to the aggregate freight locomotive and passenger locomotive ton mileage of the locomotives affected for the year, or upon some other basis deemed by the carrier to be more nearly accurate ».

Charges to superintendence (maintenance of equipment), shop machinery, power plants, floating equipment, miscellaneous equipment, injuries to persons, insurance, stationery and printing, and other maintenance of equipment expenses, are to be apportioned on the same basis as the freight and passenger proportions of repairs of locomotives and cars. The same basis is to apply to maintaining joint equipment at terminals « unless a knowledge of local conditions enables a carrier to make a more nearly accurate estimate. Each terminal should, as far as practicable, be treated individually ».

The entire group of *traffic expenses* is to be assigned directly. This is usually practicable, inasmuch as the freight traffic department and the passenger traffic department are ordinarily distinct and separate below the executive offices. Common traffic expenses are to be apportioned on the basis of the

directly assigned expenses in this general account.

In the group of *transportation expenses* no items are to be reported as undivided. The cost of dispatching trains is to be apportioned according to transportation train miles. The cost of station employees and station supplies and expenses is to be charged according to direct analysis, the common expenses to be apportioned as in the case of superintendence (to be mentioned later). Charges to weighing, inspection and demurrage bureaus, and to coal and ore wharves operation, are to be assigned directly. The yard group of expenses is to be assigned directly as far as practicable, the unassigned remainder to be apportioned in accordance with the freight and passenger yard switching locomotive miles of the year, each yard to be treated individually, if practicable, but at least excluding the mileage of those yards which have been treated as wholly freight or wholly passenger. In the cost of operating joint yards and terminals each yard or terminal is to be treated individually, and a separation made according to local conditions.

The wages of train enginemen, motormen and train crews, the cost of fuel, water and other locomotive supplies, and the cost of train supplies, are to be assigned directly as far as practicable, common expenses to be divided on the basis of the direct assignments in each account. The charges to road engine house expense are to be divided according to the number of engines handled for each class of service, an arbitrary to be used, if deemed proper, to give freight locomotives a greater weight than passenger locomotives. Operation of sleeping cars, express service and baggage claims are to be charged direct to passenger. The cost of settling freight claims is to be charged direct to freight. Charges to signal operation and crossing protection are to be apportioned on a transportation train mile basis. The expense of clearing wrecks is to be assigned directly, as far as practicable, according to the service in which the accident occurred and not according to the responsibility for the accident, the unassigned remainder to be divided (like superintendence) on the basis of the entire assignable items in the transportation expenses group. The charges for damage to property, damage to live stock on right of way, and injuries to persons, are to be treated the same as clearing wrecks. The remaining transportation accounts — namely, superintendence, train power purchased and produced operating floating equipment, stationery and printing, insurance, and other transportation expenses — are to be divided according to the freight and passenger proportions of the aggregate of the assignable items in the transportation group. The cost of operating joint tracks and facilities is to be similarly treated « unless a knowledge of local conditions enables the carrier to make a more nearly accurate estimate ».

Transportation expenses of water lines miscellaneous operations. and general expenses, are to be assigned directly as far as practicable, the remainders to be reported as undivided « unless a knowledge of local conditions makes possible a more nearly accurate estimate ».

Carriers are required to indicate the total amount of credit which should be given to the freight service for work (such as carrying company fuel and other company supplies) performed for the passenger service, and *vice-versa* ».

During the period of federal control in connection with World War I only the directly assignable expenses were reported separately for passenger and freight service, but from 1920 the scheme was revised and methods of apportionment, prescribed for all expense accounts, including maintenance of way and structures. A revised issue of the scheme for dividing expenses, effective January 1, 1936, included an extension of the analysis to cover taxes, equipment rents, and joint facility rents. *(See Appendix hereto.)*

The division of costs between passenger and freight services is usually a first step in the direction of an adequate system of cost accounting. Further cost studies relating to the relative cost of rendering

rail transportation service in various territories under varying conditions have also been developed during the last ten years by the Interstate Commerce Commission and by individual railroads.

The following table 1 from the I. C. C. Railway Statistics shows for Class I line-haul steam railways in U. S. A., the total revenues, expenses, net revenues before taxes and rents, the operating ratio and the net railway operating income for the freight and passenger service separately, from 1938 to 1944.

The division of expenses between freight service and passenger and allied services is as reported by carriers under the revised rules prescribed by the Interstate Commerce Commission, effective January 1, 1936. Small amounts of revenues and expenses reported as « not related to either freight service or passenger and allied services » have been left undivided to the extent shown in the last two colums of the table.

Such statements of economic results according to the accounting method have been made as special investigations of the Swedish State Railways. Thus the total costs of the years 1894, 1895 and 1896, specified on various cost items, were parted by means of a series of « allocation keys » to passenger, express freight, and other freight traffic. The allocation keys used were wagon-axle-kilometers, gross-ton-kilometers, train-kilometers, and the product of gross-ton-kilometers and geometric medium of the train-speed and the square of the speed. The last-mentioned allocation key was, for instance, used for allocating the maintenance costs of locomotives.

For the year 1910, there was made a calculation in Sweden of the relative profitability of passenger and various sub-branches of freight traffic in connection with a general investigation concerning the passenger and freight tariffs.

The investigation that was made by a special committee held the view « that all costs could not be distributed on traffic of various branches ». It was, however, pointed out that « one can achieve a distribution of the costs caused *directly* by the main branches

Year	Freight service					Passenger service					Unassignable	
	Revenues $ millions	Expenses $ millions	Net revenues $ millions	Operating ratio percent	Net railway operating income $ millions	Revenues $ millions	Expenses $ millions	Net revenues $ millions	Operating ratio percent	Net railway operating income $ millions	Revenues $ millions	Expenses $ millions
1938	2 942	1 968	974	66.89	626	611	744	— 133	121.81	— 255	13	11
1939	3 350	2 143	1 207	63.97	838	632	765	— 133	120.98	— 251	13	11
1940	3 647	2 297	1 350	62.98	943	635	780	— 145	122.89	— 262	15	12
1941	4 585	2 799	1 786	61.05	1 223	751	857	— 105	114.02	— 226	10	8
1942	6 111	3 549	2 562	58.07	1 394	1 348	1 047	301	77.69	89	7	5
1943	6 966	4 302	2 664	61.76	1 080	2 080	1 347	733	64.77	280	9	8
1944	7 178	4 746	2 432	66.12	871	2 248	1 527	721	67.93	234	11	9

Table 1.

of the traffic, in a way at least mainly satisfactory ». By direct costs (variable costs) for e. g. the passenger traffic the committee meant such costs that would disappear if the passenger traffic were withdrawn. The committee first divided the various items of total costs into constant and variable costs. As soon as a cost was stated to be constant, it was put aside and thus not allocated to the various branches.

The cost items considered to be variable were, on the other hand, allocated, either directly or by means of various proportionality factors, to four operation cost groups, resp. train costs, waggon costs, switching costs, and station costs; hereby these variable costs were also distributed among traffic branches, i. e. passenger traffic, freight traffic, iron ore traffic etc.

The final result of this calculation is given below :

	Revenues cr., millions	Direct (variable) costs cr., millions	Surplus to cover constant costs cr., millions
Passenger traffic	28.4	19.9	8.5
Freight traffic	32.0	22.9	9.1
Iron ore traffic.	9.8	3.5	6.3
Service transport	2.5	2.5	—
Harbour traffic.	0.5	0.5	—
Miscellaneous income	1.4	—	1.4
Total . . .	74.6	49.3	25.3
Amount of constant costs. . .			30.6
Deficit.			5.3

According to this calculation 62 % of the total costs were ascertained to have been incurred exclusively by one or another class of traffic and 38 % were costs common to the traffic as a whole.

Yearly statistical profits and loss statements of different classes of traffic have recently been prepared by the Norwegian State Railways, the South African Railways and the Swedish State Railways. As regards the general methods of calculation, the yearly statements of these three railways are principally the same, all are variants of the accounting method, although they as a consequence of, among other things, the different economic and technical conditions of the countries, may differ in various details. As an illustration of how a profit and loss statement for different classes of traffic may be prepared according to the accounting method we have chosen to give a short account of the Swedish version of this method.

A scheme for current distribution of the operating expenses and revenues between various traffic branches, partially after

American and German patterns, was introduced in 1930 by the Swedish State Railways and was carried on up to 1939, when it was abandoned. It is intended that such statements of economic results, partially with another outlining and shaping and more tending to the prospective method, are soon to be taken up again in Sweden.

It has been pointed out above that the operating expenses in different degrees can be distributed between the various traffic branches. Certain costs can directly be attributed to certain traffic branches (separable costs), while others (common costs) can be distributed among the various traffic branches only by means of more or less reasonable allocating methods. In the Swedish profit and loss calculations during the period of 1930-1939 the various costs items in this distribution among various classes of traffic were gathered in the following three main groups :

1. Directly assignable expenses (« Direct expenses »);

2. Indirectly apportionable expenses (« Indirect expenses »);

3. Undividable expenses (« Proportioned expenses »).

The first group, « direct expenses », which, for instance, in 1938 amounted to about 68 % of the total expenses, included expenses for station staff, train staff, engine staff, traction fuel and current, maintenance and renewal of locomotives, and rolling stock in general.

The expenses under these headings were directly assigned month to month to the various classes of traffic concerned, i. e. passenger traffic and luggage traffic, express traffic, post conveyance, ordinary goods in less than carloads (LCL), ordinary goods in carloads (CL), and iron ore traffic. The separation of the expenses was made by accounting sections (traffic sections resp. engine sections).

The station staff expenses were separated between various classes of service and operations in accordance with a specification, drawn up once a year for a representative month for every station, showing how the working hours for every member of the staff had been distributed (in per cent) between the various duties in the station service. Due regard hereby was taken to the varying wages per hour, paid to employes of different classes.

The station staff expenses were received in that way either directly for the classes of traffic under study, i. e. ordinary passenger traffic and luggage, suburban passenger traffic, mail traffic, fast freight traffic, freight in less than carloads (LCL), freight in carloads (CL) and iron ore traffic, or for train or yard operations, common for two or more classes of traffic. These common expenses of e. g. train dispatching, shunting etc., were distributed among the various classes of traffic on the basis of the work performed. Rather detailed station statistics were kept by all stations, which registered the appropriate units of measurement of station production in the various classes of station operations. The main aim of this station expense allocation was to separate the separable (direct) costs which were peculiar to the various classes of traffic, into individual groups and to divide the remaining expenses in a manner that permits their apportionment on the basis of the work performed.

Train staff expenses were separated between the various classes of trains in proportion to the number of hours spent. A specification of the hours spent was procured by means of the service lists of the guard personnel. Train staff expenses of trains, common to two or more classes of traffic, were distributed between the traffic classes concerned in proportion to the axle-kilometers for these classes.

Engine staff expenses were separated between the various classes of trains in proportion to the number of hours spent. A specification of the train-hours in various trains were procured from the service lists of the personnel.

Engine house expenses were divided according to the number of engines handled for each class of train.

Train fuel, lubricants, etc., expenses were separated between the different classes of

trains according to periodic test figures for the consumption of fuel, etc., for various types of locomotives and classes of trains. *Electric power* consumption was distributed to the different classes of trains according to technical data.

Expenses of maintenance and depreciation (renewal) of equipment were obtained by the workshops accounting system for various types of locomotives and cars. The expenses of each type of equipment were distributed among different classes of trains in relation to the work performed in these classes of trains, measured as regards maintenance by locomotive-kilometers and car-kilometers and as regards depreciation by locomotive-hours and car-hours.

Thus, after having been separated to various classes of trains, the above-mentioned expenses of train operation then were either assigned directly to a certain class of traffic, or as regards costs of trains common to two or more classes of traffic, distributed between the classes of traffic concerned in proportion to the car-kilometers of these classes.

The expenses of *yard switching* were separated between verious classes of traffic according to the data from periodic tests of each switching yard.

Depot staff expenses are subjected to a complete per cent distribution among the materials and stocks treated by the depot service. Thus these expenses were included in the prices of the various materials, especially fuel, rails, sleepers, etc., consumed in railway operation.

Social charges were included in the salaries and wages of the various groups of employees,

This separation of the expenses of the first group (« direct expenses ») of the various operating divisions of the railway system between the different classes of traffic was prepared each month. A special statement of the whole railway system, showing revenues, direct expenses and the surplus of revenues above direct expenses of the different classes of traffic was also made monthly.

The *second group of expenses*, « *indirect expenses* », which e. g. in 1938 amounted to about 27 % of the total expenses, included expenses of *maintenance and depreciation of way and structures*. These expenses were not apportioned monthly, but only at the end of the year to various classes of traffic.

Expenses of *inspection* of running tracks were distributed in proportion to the train-kilometers of the various classes of trains. Expenses of *maintenance and depreciation of way* were first divided between yard tracks and running tracks in relation to the relative length of the two classes of tracks. The yard track expenses were then apportioned to the various classes of traffic on the basis of the relative switching costs of these classes of traffic. The expenses of running tracks were apportioned to different classes of trains on the basis of gross ton-kilometers. Expenses of maintenance and depreciation of *buildings* were apportioned to various classes of traffic in proportion to the directly assigned expenses of the service group in question.

Expenses primarily calculated for various classes of trains, were apportioned between the different classes of traffic on the basis of the car-kilometers by the respective category of train in each class of traffic.

The *third group*, « *proportional expenses* », consisting of general expenses and other expenses that are not directly assignable or indirectly apportionable were allocated according to the proportions of the calculated direct and indirect expenses of the various classes of traffic.

The profit and loss statements of the different classes of traffic of the Swedish State Railways during the period of 1931-1938 are given in *table* 2, showing direct, indirect and proportioned expenses, revenues, surplus of revenues above direct expenses and surplus or deficit (profit or loss) of revenues above total allocated expenses of the different classes of traffic.

Some railways go even further in their profit and loss statements than to the particular classes of traffic, and through further splitting up of revenues and expenses common to two or more sub-classes of traffic.

TABLE 2.

Operating expenses and revenues of different classes of traffic, 1931-1938, in million sw. crowns.

1. *Direct expenses.*

	1931	1932	1933	1934	1935	1936	1937	1938
Passenger, luggage	44.56	46.00	46.14	47.00	48.96	52.22	58.44	62.08
Fast freight	9.58	9.47	9.31	9.31	9.30	9.38	9.67	9.85
Mail traffic	3.66	3.80	3.90	3.82	3.90	3.91	4.13	4.34
Ordinary freight in less than carloads (LCL)	17.80	17.87	17.94	18.04	18.22	18.54	19.24	19.17
Ordinary freight in carloads (CL). .	28.51	26.60	24.88	25.45	26.42	26.92	30.19	31.47
Iron ore traffic	5.81	4.44	3.80	4.07	4.68	5.42	6.92	7.46
Total . . .	109.91	108.18	105.98	107.70	111.46	116.40	128.60	134.38

2. *Indirect expenses.*

	1931	1932	1933	1934	1935	1936	1937	1938
Passenger, luggage	11.96	12.93	12.27	12.69	13.40	14.80	18.56	21.30
Fast freight	2.21	2.27	2.10	2.11	2.20	2.23	2.33	2.71
Mail traffic	0.90	0.98	0.86	0.98	0.97	1.02	1.15	1.35
Ordinary freight in less than carloads (LCL)	5.54	5.80	5.57	5.83	6.07	6.56	6.26	7.11
Ordinary freight in carloads (CL). .	12.30	10.76	10.28	11.84	12.49	12.94	16.46	18.28
Iron ore traffic	3.66	2.91	2.64	2.91	3.29	3.54	4.21	4.62
Total . . .	36.57	35.64	33.72	36.36	38.42	41.08	48.96	55.36

3. *Proportioned expenses.*

	1931	1932	1933	1934	1935	1936	1937	1938
Passenger, luggage	4.89	5.08	5.68	5.93	6.05	6.86	7.29	7.95
Fast freight	1.10	1.03	1.09	1.13	1.14	1.23	1.16	1.28
Mail traffic	0.40	0.34	0.39	0.44	0.46	0.49	0.48	0.54
Ordinary freight in less than carloads (LCL)	2.12	2.06	2.26	2.38	2.46	2.63	2.48	2.71
Ordinary freight in carloads (CL) . .	0.16	—0.08	0.16	0.22	0.59	0.57	0.82	1.26
Iron ore traffic	0.71	0.49	0.49	0.55	0.64	0.78	0.84	0.98
Total . . .	9.39	8.92	10.07	10.66	11.35	12.56	13.06	14.72

4. *Total expenses* (1 + 2 + 3).

	1931	1932	1933	1934	1935	1936	1937	1938
Passenger, luggage	61.40	64.00	64.10	65.62	68.40	73.88	84.29	91.33
Fast freight	12.88	12.77	12.50	12.56	12.64	12.84	13.16	13.84
Mail traffic	4.97	5.12	5.15	5.24	5.34	5.41	5.76	6.24
Ordinary freight in less than carloads (LCL)	25.46	25.72	25.77	26.25	26.75	27.72	27.98	28.99
Ordinary freight in carloads (CL) . .	40.97	37.28	35.32	37.52	39.50	40.43	47.46	51.01
Iron ore traffic	10.18	7.84	6.93	7.54	8.60	9.74	11.98	13.06
Total . . .	155.87	152.74	149.77	154.72	161.23	170.04	190.62	204.47

5. *Total revenues.*

	1931	1932	1933	1934	1935	1936	1937	1938
Passenger, luggage	66.14	61.33	60.22	66.26	71.23	76.45	82.90	88.45
Fast freight	10.58	9.74	9.96	10.63	10.99	11.45	11.97	12.46
Mail traffic	8.19	8.00	8.00	8.28	8.41	8.86	9.44	9.84
Ordinary freight in less than carloads (LCL)	19.32	17.25	17.85	20.26	21.80	23.35	25.46	26.04
Ordinary freight in carloads (CL). .	59.54	51.01	51.85	60.52	64.75	68.40	78.49	76.12
Iron ore traffic	15.34	16.91	16.25	15.96	17.47	19.00	29.63	35.89
Total . . .	179.10	164.23	164.13	181.92	194.64	207.51	237.90	248.80

6. *Surplus or deficit of revenues above direct expenses* (5 — 1).

	1931	1932	1933	1934	1935	1936	1937	1938
Passenger, luggage	21.58	15.33	14.08	19.26	22.27	24.23	24.46	26.37
Fast freight	1.00	0.27	0.65	1.32	1.69	2.07	2.30	2.61
Mail traffic	4.63	4.20	4.10	4.46	4.51	4.95	5.31	5.50
Ordinary freight in less than carloads (LCL)	1.52	—0.62	—0.09	2.22	3.58	4.81	6.22	6.87
Ordinary freight in carloads (CL). .	31.03	24.41	26.97	35.07	38.33	41.48	48.30	44.65
Iron ore traffic	9.53	12.47	12.45	11.89	12.79	13.58	22.71	28.43
Total . . .	69.19	56.05	58.15	74.22	83.18	91.11	109.30	114.42

7. *Surplus or deficit of revenues above total expenses* (5 — 4).

	1931	1932	1933	1934	1935	1936	1937	1938
Passenger, luggage	4.74	—2.67	—3.88	0.64	2.83	2.57	—1.39	—2.88
Fast freight	—2.30	—3.03	—2.54	—1.93	—1.65	—1.39	—1.19	—1.38
Mail traffic	3.22	2.88	2.85	3.04	3.07	3.45	3.68	3.60
Ordinary freight in less than carloads (LCL)	—6.14	—8.47	—7.92	—5.99	—4.95	—4.37	—2.52	—2.95
Ordinary freight in carloads (CL). .	18.57	13.73	16.53	23.00	25.25	27.97	31.03	25.11
Iron ore traffic	5.16	9.07	9.32	8.42	8.87	9.26	17·65	22.83
Total . . .	23.23	11.49	14.36	27.20	33.41	37.47	47.28	44.33

they are able to compute such statements also of various lines or groups of lines and of different classes of travel, i. e. 1st, 2nd and 3rd.

Concerning the economic data given above under 7. (« Surplus or Deficit of Revenues above Total Expenses »), the following commentary may be added. The result of a surplus and deficit calculation for various classes of traffic, such as this one which on the cost side to a very great extent contains allocated common and constant costs, says nothing about the profitability of the different classes of traffic judged from the viewpoint of the whole enterprise, which however is the only economically relevant basis for judgment which can be applied to anyone of the branches of production included in the enterprises operation. Thus, a deficit according to a calculation of the above mentioned type need not mean that a discontinuance of the class of traffic in question will increase the profits of the whole enterprise, but only that the class of traffic in question does not contribute to the common costs of the whole of the railway traffic in the same proportion as those classes of traffic which allow a surplus. On the other hand, the revenues of the class of traffic in question may, in spite of this deficit, be considerably greater than the subtractional costs, which would be saved if the class of traffic were discontinued, for which reason the class of traffic in question actually contributes toward the increasing of the whole enterprise's profits to the extent that these revenues exceed these subtractional costs. It pays therefore to retain such classes of traffic as long as they make at least some contribution to the covering of the common and constant costs of production and, thus, through their existence, increase the entreprise's profits.

Therefore, in practical business policy, when it is a matter of choosing between several possible alternatives of action, profit and loss statements according to the accounting method cannot give any direct indication to an economically rational choice. In order to make the economic consequences clear and thus facilitate a choice between different possible alternatives of action, concerning price policy as well as production and investment policy of the railway enterprise, the calculation method in section IV, called « the alternative budget method » or « profitability estimations », must be used instead.

Even though such profit and loss state-

ments prepared by the accounting method are not directly usable when it is a matter of choosing between different economic alternatives of action in practical business policy, they may nevertheless be of value in judging the *development* of expenses and revenues of different branches of business and can, when made in an appropriate way and put together for a sequence of years, serve as a guide in the work of increasing the efficiency of the business.

Thus, in a railway enterprise, if one wants to study the economic development of, for example, *different classes of traffic* during a continuous period of years, a rather good survey should be obtained through the following modification of the accounting method, which modification a special government committee has proposed should be used in the Swedish State Railways. For each class of traffic and year, there are first rendered accounts regarding the separable costs of the class of traffic in question, after which these costs are divided up into two parts, namely those which upon a temporary discontinuance of the class of traffic in question would be variable costs, and those which would remain constant costs. It should be particularly called to attention that this calculation will not be used for judging whether the traffic should be temporarily discontinued but that it has been introduced in order to get a division of the costs into variable and constant costs. A situation with temporarily discontinued traffic should almost correspond to a disappearance of expenses of operating personnel, materials and rolling stock, while on the other hand expenses of permanent way and structures will remain. After this specification of the separable costs of the different classes of traffic, the revenues of each kind of traffic are stated, which receipts in this case could be obtained completely as separable revenues of the respective classes of traffic. The difference between revenues and separable costs constitutes the « surplus above separable costs » (« out-of-pocket profits or losses ») of the classes of traffic in question. Such a calculation for all classes of traffic having been carried out, the expenses common to two or more classes of traffic are stated. These expenses are divided up in such a way that, in a case of temporary discontinuance of the traffic, they could be considered as variable and constant costs, respectively. The difference between the sum of the surpluses of the different classes of traffic, mentioned above, and the common expenses constitutes the enterprise's total net revenue.

Often a result more interesting and illuminating from a business-economic point of view can be obtained by regrouping the above named cost categories in such a way that accounts regarding the *variable separable costs* of each class of traffic are rendered first, after which the *variable common costs* of two or more classes of traffic — which generally should consist of personnel and material costs — *are divided up* among the different classes of traffic, which division often may be possible to perform in a way relatively satisfactory from an economic standpoint. In this way a *first approximation* for each class of traffic is obtained to the *variable* costs (subtractional costs) which could be expected to be saved if the class of traffic in question were temporarily discontinued. If the revenues of the various classes of traffic are compared with these variable costs, the « surplus above variable costs » of the classes of traffic can be found. After such an operation is performed for all classes of traffic, it might also be convenient to state in the survey both the constant separable costs of the class of traffic in question and the constant common costs, jointly caused by two or more classes of traffic. If the constant separable costs of the classes of traffic as well as the variable costs are deducted from the revenues of the various classes of traffic, the « surplus above variable costs and constant separable costs » of the different classes of traffic is obtained. The enterprise's net-revenue is finally obtained by deducting the constant common costs from the sum of the last named surpluses. In conclusion, the different links in this separate rendering of economic results of different classes of traffic can be shown in the following way :

	Class of traffic		
	A	B	C
Revenues (1)	R_A	R_B	R_C
Variable costs (2) . . .	C^V_A	C^V_B	C^V_C
Surplus above variable costs (3) = (1)-(2) . .	S^V_A	S^V_B	S^V_C
Constant separable costs (4)	C^C_A	C^C_B	C^C_C
Surplus above variable costs and constant separable costs (5) = (3)-(4)	S^{VC}_A	S^{VC}_B	S^{VC}_C
Constant common costs (6)	C^C_{A+B+C}		
Net revenue (7) = (5)-(6)	Y		

As the calculation of the constant costs (items (4) and (6) above) becomes rather undefinite, above all because of the fact that depreciation costs will vary with variations in prices of assets, etc., the development of the surplus above variable costs of the different traffic classes (item (3) above) often allows a more reliable estimation of the economic development of the enterprise than a study of the surplus that is received after subtraction also of the constant separable costs (item (4) above).

These surplus and deficit calculations become considerably more difficult with regard to those branches of production, where the revenues are not separable, as they were above with regard to the various classes of traffic, but common for two or more branches, *common revenues*. This is the case, if one wants to prepare surplus and deficit statements of different lines or sections of the railway system. Then one usually allocates the revenues common to two or more lines between the different lines in proportion to the number of kilometers that the transports in question have covered on the lines in question. The more and the shorter the individual lines are, used in such calculations, the less becomes, relatively seen, the traffic within each individual line (the intra-line traffic), the revenues of which are separate revenues of the line in question, and the greater becomes that part of the line's traffic that is common to this and other lines (the inter-line traffic), the revenues of which are common revenues. An economically adequate allocation of such common revenues between different lines or groups of lines is only possible in rare cases of exception. In order to eliminate this allocation problem as extensively as possible, one therefore has to confine the calculations to a smaller number of lines or groups of lines, where thus to a high degree the traffic within each line or group of lines consists of intra-line traffic, by which fact, as mentioned before, the greater part of the revenues of the individual lines or groups of lines become separable revenues. Also with regard to the costs there are reasons for confining these regional calculations of surplus and deficit to a smaller number of lines or groups of lines. Hereby the common expenses of the individual lines or groups of lines become relatively small and the main part of the costs are separable costs. Even if thus, by choosing greater groups of lines as objects of these regional statements of economic results, the common revenues and common costs, joint for several lines or groups of lines, can be cut down considerably, the remaining common revenues and common costs, will often be of a relatively important magnitude in spite of all.

VI. — The alternative budget method.
(Profitability estimations)

In the preceding parts, especially in part III, it has been stressed that the railway enterprise, for a rational shaping of its

business policy, needs a type of calculation, then called profitability estimations or the alternative budget method, which consists of estimating what changes a certain acting alternative (business plan) can be expected to cause in the expenses, revenues and net-revenues of the enterprise in comparison with the case that the plan in question is not executed or a certain other plan is chosen. By such profitability estimations one thus obtains statements of the net-value of various possible plans of the enterprise, by which statements it is also possible to estimate the relative value of each of these plans.

Provided the aim of the enterprise activity is to obtain a maximum net-revenue the general profitability criterion can be stated in the following way. Each business-political measure (changes in rates and fares, of quality with regard to the services sold, changes in the size of plants, etc.) is profitable for the enterprise as a whole if there is an increase of the total net-revenues of the enterprise, caused by the measure in question.

If one regards especially the calculation problems which are of interest in this context, i. e. the profitability of the passenger service resp. the freight service as a whole, the problem is, how the total expenses of the railway enterprise, its revenues and net-revenues would be influenced, if the traffic class in question were withdrawn as a whole, but the rest of the traffic would continue to exist.

If it shall be profitable for the enterprise to maintain the production of a certain product or in a certain production branch, it is necessary that the subtractional revenues that the enterprise would lose, if the production in question was discontinued, are greater than the subtractional costs, that the enterprise would save by such a measure. If, on the other hand, the question is to begin a new production branch, this is only profitable provided the additional revenues, obtained by the enterprise, are greater than the additional costs caused by this new production branch. This is thus the criterion of the profitability of maintaining or starting a certain traffic (traffic branch, etc.). seen as a whole.

Also with regard to smaller variations of the amount of traffic already existing (increases or decreases), which can arise either automatically or in consequence of active price-policy or other measures, taken by the railway enterprise, the profitability criterion will be the same, i. e. every increase of traffic that is followed by a greater additional revenue to the railway enterprise than the additional costs caused by the traffic increase, respectively every decrease of traffic which occasions a greater subtractional cost than the subtractional revenue caused by the decrease of traffic, will be profitable for the railway enterprise.

In general the enterprise has, in a certain situation, the possibility to choose between several different acting alternatives, not only one of which, but also several, can be profitable for the enterprise in the sense mentioned before. The most profitable of the existing alternatives is of course the one that brings the greatest increase of net-revenues of the enterprise as a whole.

Even if, in case of a « withdrawal-calculation » for a certain branch of traffic, it should turn out that the subtractional costs are greater than the subtractional revenues, i. e. one would save more in costs than one would loose in revenues by withdrawing the branch of traffic in question, it need not be sure that this acting alternative should be the most profitable for the enterprise. Only provided that the costs vary in direct proportion to the changes in the amount of traffic in the branch of traffic in question (« proportional costs »), the deficit of the present amount of the traffic will become greater than in case of a total withdrawal of the traffic. If, on the other hand the relative change of the costs is smaller than the relative change of the amount of traffic, i. e. the costs are *degressive*, the deficit of the present amount of traffic can of course, as in case of proportional costs, be greater than in case of a total withdrawal of the traffic; but as the costs of an increase of the traffic usually increase relatively slower than the traffic, the deficit of the present amount of traffic will diminish when the traffic increases, if it is possible to obtain

such an increase of traffic without, or with not too much, changing (i. e. lowering) the tariffs. In case of a sufficiently strong increase of traffic the present loss could possibly, because of the lowering of the costs, be expected to turn into a surplus of the traffic branch in question. From a business-economical point of view it depends thus on the circumstances in the single case, if one is to withdraw entirely or to increase the production. If, finally the costs should be *progressive*, i. e. increase resp. decrease relatively faster than the traffic, the loss would diminish provided that the traffic was reduced and, in case of a sufficiently great reduction of traffic, probably turn into a surplus. In this case, therefore, it will be most profitable to reduce the traffic somewhat, but not to withdraw it completely.

As mentioned before, a « full cost », calculated by allocating common and constant costs can only exceptionally be expected to correspond to the additional or subtractional costs relevant for business policy. Therefore a price and production policy based on such calculated full costs will probably lead to a decrease of the profit of the enterprise.

In the following it shall be made clear by means of some examples how one can prepare these profitability estimations, necessary for a rational business policy, with regard firstly, to the passenger traffic resp. the freight traffic as a whole, and secondly to a certain increase of the amount of traffic for passenger traffic resp. freight traffic.

Thus, in the first case one endeavours to obtain a conception of the profitability of passenger and freight traffic as a whole. In this case one postulates that the passenger, respectively the freight traffic, are withdrawn alternatively, but that the rest of the traffic is maintained. Thus the question here is about a hypothetic calculation, as one in several cases might doubt that the freight traffic could be maintained unchanged, if the passenger traffic was entirely withdrawn, and vice versa. One has to try to estimate for each single item of operating expenses in what way this should be altered, if the traffic class in question was withdrawn. These calculations must, of course, become approximative (a sort of intelligent guessing), but with practical operating experience as a basis one ought to come to a rather right estimate of, how the economy of the railway can be expected to be influenced by such a measure. Such calculations have been executed in several cases in Sweden during the last decenniums. This was usual with regard to individual lines of the railway system, situated in districts, where there was very keen competition by motor transport and where in consequence either the passenger traffic or the freight traffic or both of them had decreased so in volume, that the question of a complete or partial withdrawal was actualized.

In order to make clear how these calculations are prepared and what use one can have of them for practical business policy, some especially instructive examples from a Danish traffic investigation of the 1930-ies will be cited here. The profitability estimations embraced four private railways with different structure as regards traffic and operating conditions. *In table* 3 below are gathered amounts of traffic and operating expenses of these four railways, termed A, B, C and D.

If the passenger traffic, respectively the freight traffic should be withdrawn entirely, a saving of operating expenses (subtractional costs) could be expected, as it is made clear by the following *table* 4. By subtracting these savings in passenger, respectively freight traffic, obtained by the withdrawal of the traffic, from the total operating expenses in table 3, one obtains as a rest the expenses in case the railway in question should be operated as a freight railway only, and if one, on the other hand, subtracts the savings in case of a withdrawal of the freight traffic from the total operating expenses, one obtains as a rest the expenses of the railway, operated as a passenger railway only. These operating expenses of the railway, operated as a passenger railway, respectively freight railway only, are also shown in table 4.

TABLE 3.

RAILWAY	Passenger-km		Freight ton-km		Operating expenses, crowns	
	Total	per km of road	Total	per km of road	Total	per km of road
	Thousands					
A	6 521	180	1 540	42.0	483	13.3
B	4 183	118	1 212	34.0	392	11.0
C	2 561	61	566	13.5	284	6.8
D	1 270	27	311	6.6	184	4.1
Total	14 535	—	3 629	—	1 343	—
Average for A-D	3 634	90	907	22.5	336	8.3

TABLE 4.

RAILWAY	Savings in expenses (crowns) by discontinuing		Operating expenses (crowns) when the railway is operated	
	Passenger service	Freight service	Only for passenger service	Only for freight service
	Thousands			
A	203.6	156.7	326.3	279.4
B	142.8	129.5	262.6	249.3
C	95.5	113.7	170.6	188.8
D	55.6	47.6	136.1	128.1
Total	497.5	447.5	895.6	845.6
Average for A-D	124.4	111.9	223.9	211.4

Considering the average figures of all railways in this table, one finds that the part of the expenses that can be ascribed to the passenger traffic is not greater than 224 000 Cr., which corresponds to the amount that it would cost to run the railway as a passenger railway only, without freight traffic. On the other hand, the

expenses of the passenger traffic must not be less than 124 000 Cr., which corresponds to the amount that should be saved, if the passenger traffic was withdrawn entirely or, to express it in another way, the amount by which the expenses can be expected to be increased, if a mere freight railway starts passenger traffic of the size in question here.

In the same way can be determined an inferior limit and a superior limit of that part of the expenses that can be distributed to the freight traffic, and one finds thus that the minimal expenses is 112 000 Cr. and the maximal expenses 211 000 Cr. If the expenses thus calculated are put in relation to the amount of the traffic in person-kilometers and ton-kilometers, the following *table* 5 can be formed :

TABLE 5.

RAILWAY	Expenses (öre) per passenger-km		Expenses (öre) per freight ton-km	
	Minimum	Maximum	Minimum	Maximum
A	3.12	5.00	10.18	18.15
B	3.41	6.28	10.68	20.57
C	3.73	6.66	20.09	33.35
D	4.38	10.72	15.31	41.19
Average for A-D. . . .	3.42	6.16	12.33	23.31

The differences given in the table between the maximal and minimal expenses for passenger, respectively freight traffic is caused by the fact that a part of the expenses of the railways are common and constant expenses which are not influenced, if a certain traffic class is withdrawn.

This is as far as one can go, from a theoretical point of view, with the distribution of the total costs of the traffic between the two classes of traffic, passenger and freight traffic. Practically, one will often go further with this distribution and also divide the common and the constant expenses, without rest, between the two classes of traffic. One is then compelled to introduce special assumptions as a basis for this allocation which assumptions can be more or less arbitrary. Such an allocating basis which is often used in various public utilities, and which, both from a theoretical and from a practical point of view seems to be very motivated, is the following which has also been applied with regard to the four railways here concerned. If one postulates a mere passenger railway of the average type here concerned, the annual operating expenses are 224 000 Cr., and further if it is presumed that the expenses for a mere freight railway are 211 000 Cr., the sum of both expenses is 435 000 Cr., when they are operated each apart. If the passenger traffic and the freight traffic are operated together, the operating becomes cheaper, and the annual expenses are then 336 000 Cr., which is equal to a saving of 99 000 Cr. or 23 % of the 435 000 Cr. If one now wants to distribute the savings that is caused by joining the operations of passenger and freight traffic, it seems to be very motivated that this is performed uniformly upon both classes of traffic. The expenses of the

passenger traffic will then decrease by 23 % from 224 000 Cr. to 173 000 Cr., and the expenses of the freight traffic likewise by 23 % from 211 000 Cr. to 162 000 Cr. The amounts of expenses thus calculated for passenger and freight traffic, which could be termed *standard expenses*, are to be found in *table* 6, and likewise the above calculated minimal and maximal expenses, and the revenues of the four railways. All statements are made in öre per passenger-kilometer, respectively per ton-kilometer.

TABLE 6.

RAILWAY	PASSENGER SERVICE			
	Minimum expenses	Maximum expenses	Standard expenses	Revenues
	öre per passenger-km			
A	3.12	5.00	3.99	5.59
B	3.41	6.28	4.81	5.24
C	3.73	6.65	5.27	5.66
D	4.38	10.72	7.45	5.84
Average for A-D. . . .	3.42	6.16	4.75	5.52
RAILWAY	**FREIGHT SERVICE**			
	Minimum expenses	Maximum expenses	Standard expenses	Revenues
	öre per freight ton-km			
A	10.18	18.15	14.47	11.47
B	10.68	20.57	15.76	11.05
C	20.09	33.35	26.38	18.06
D	15.31	41.19	28.64	12.66
Average for A-D. . . .	12.33	23.31	17.98	12.46

It appears from this table that the revenue per passenger-kilometer of all four railways is 5.52 öre and the standard expense 4.75 öre, so the passenger traffic leaves a surplus. The freight traffic, on the other hand, has a revenue of 12.46 öre per ton-kilometer and a standard expense of 17.98 öre, that means a rather considerable deficit. In average for all four railways, the freight traffic pays barely its minimal expenses of 12.33 öre, corresponding to the expenses caused directly by freight traffic, and which would be saved, if the freight traffic was withdrawn.

As to the single railways, they show some deviations from the average results. Concerning the passenger traffic railway A has a great surplus in comparison with the standard expenses, while the surplus of the

railways B and C is of a more moderate amount, and railway D finally has a great deficit of the passenger traffic. The freight traffic gives for all four railways a considerably smaller revenue than the standard expense per ton-kilometer. For the railways C and D the revenues are moreover smaller than the minimal expenses, while in maintenance of equipment and about 40 % in train and station service. As to maintenance of way and general administration the savings were calculated to be only 20 %. The savings for the single railways vary of course in different expense items because of differences in the operating and traffic structure of the railways.

TABLE 7.

	Road A	Road B	Road C	Road D	Total for road A-D
	crowns, thousands				
Passenger service :					
Total revenues	364.8	219.3	144.9	74.1	803.1
Minimum expenses for passenger service	203.6	142.8	95.5	55.6	497.5
Surplus of revenues above minimum expenses = contribution of passenger service to common expenses . . .	161.2	76.5	49.4	18.5	305.6
Freight service :					
Total revenues	176.7	134.0	102.2	39.3	452.2
Minimum expenses for freight service	156.7	129.5	113.7	47.6	447.5
Surplus of revenues above minimum expenses = contribution of freight service to common expenses . . .	20.0	4.5	— 11.5	— 8.3	4.7

the revenues of the railways A and B rarely pay the minimal expenses, i. e. the expenses directly caused by the freight traffic (subtractional costs).

Totally for the four railways, the total expenses would decrease by 37 % in case of withdrawal of the passenger traffic. The savings for the single railways vary between 30 and 42 %. The savings in the operating expenses are, however, very different in different expense items, amounting to 48 %

The savings that would be made, if the freight traffic was withdrawn deviate rather considerably in magnitude from those calculated above in case of withdrawal of the passenger traffic. Thus the average savings have been calculated for the four railways together to 33 % and vary for the single railways between 27 and 40 %. For three of the railways the savings by withdrawal of the freight traffic would be smaller than by withdrawal of the passenger

traffic; but for railway C these savings were calculated to be 40 % against 34 % in case of withdrawal of the passenger traffic.

The greatest savings by withdrawal of the freight traffic are made in station expenses, where they amount to 47 %, and in train expenses, where they are 41 %. In maintenance of equipment the savings are 30-35 %, in administration 25 %, and finally in maintenance of way only 8 %. Also in each of the railways. By subtracting the minimum expenses of the passenger traffic from the total revenues of the passenger traffic the contribution of the passenger traffic to the common expenses is obtained; the meaning of « common expenses », is as mentioned before, expenses that are caused toby both the passenger and the freight traffic, but which cannot be directly ascribed to one of these classes of traffic. A similar

TABLE 8.

	Road A	Road B	Road C	Road D	Total for road A-D
	crowns, thousands				
Total expenses of the road	483.0	392.1	284.3	183.7	1.343.1
Whereof : Minimum expenses for passenger service	203.6	142.8	95.5	55.6	497.5
For freight service	156.7	129.5	113.7	47.6	447.5
Remainder = Common expenses . . .	122.7	119.8	75.1	80.5	398.1
Common expenses are covered by surplus of revenues above minimum expenses from :					
Passenger service	161.3	76.5	49.4	18.5	305.6
Freight service	20.0	4.5	— 11.5	— 8.3	4.7
Surplus or deficit of revenues above common expenses.	58.4	— 38.8	— 37.2	— 70.3	— 87.8

the freight traffic the relative savings are different for the single railways, which is explained, as mentioned before, by their different operating and traffic structure.

A general survey of the importance of the two classes of traffic for the economy of the four railways can be obtained from *table* 7, where the total revenues, minimum expenses, and surplus of revenues of both passenger and freight traffic are given for calculation was made for the freight traffic, which showed clearly that the contribution of the freight traffic to the common expenses was very small, and that two of the railways. (C and D) gave a negative contribution, i. e. the revenues of the freight traffic of these two railways did not pay the minimal expenses.

In *table* 8 above the statements given before have been arranged in another way,

so that the total expenses of the railways are given first and then the minimum expenses of passenger, respectively freight traffic. By subtracting these two minimal expenses from the total expenses of the railway in question, a remainder is obtained which can be said to correspond to the common production expenses. These common production expenses are paid by revenues (above the minimal expenses) from the passenger, respectively freight traffic, and here arises a surplus for railway A, while there is a deficit for the railways B, C and D. The contribution to the common production expenses is mainly due to the passenger traffic, while the contribution from the freight traffic is very small and even negative for the railways C and D. It may be of interest to realize in this context, that while it was often regarded as nearly a general rule that it is above all the freight traffic that contributes to the paying of the common and constant costs of the railway traffic, in the case of these four Danish private railways, it was the passenger traffic that was of the greatest importance for covering of these common expenses.

The calculations given above are to show, how the economy of the railways can be expected to be influenced by a complete withdrawal of a certain class of traffic. Similar profitability estimations can of course also be performed for smaller variations in the amount of the passenger or freight traffic, and such calculations for smaller variations are the most usually needed in practical business policy.

A comparison between the subtractional expenses and revenues of two different classes of traffic as a whole yields very little material for a judgment e. g. of the shaping of the concrete price policy with regard to these classes of traffic which, as to each single class, may contain differentiationsin tariffs of various kinds, with regard to the length of the haul, the value of the various kinds of goods, the intensity of the competition, etc. Practically the price policy therefore mainly consists of measures with regard to smaller parts or segments of traffic. An example of such a profitability estimation of a smaller variation in the amount of the traffic is given below. Also this example is taken from the Danish investigation, mentioned above. With regard to the railways A and B it was thus calculated how the expenses would be influenced in case of an increase of the amount of traffic by 25 %, provided that this increase was uniform in percentage in the whole railway system and during the whole year; the peak load increased thus by 25 %. The main results of these calculations may be seen in *table* 9. At the same time it was presumed that this increase of traffic could be obtained without changing the tariffs. The table indicates that there is a considerable difference between the passenger and the freight traffic with regard to the question how the increase of traffic influences expenses and revenues. An increase of the passenger traffic brings on very small additional expenses compared with the additional revenues that are obtained, while the additional expenses caused by an increase of the freight traffic are more than half of the arising additional revenues.

VII. — SUMMARY.

1. Unprofitable parts or branches of railway traffic can be localized by cost and revenue analysis. Management is then in a position to decide if and in what way the losses of these branches can be reduced and possibly turned into profit. In the railway industry such cost and revenue analyses in order to determine the relative profitability of different branches of traffic are almost as old as the railways themselves.

2. Calculations of net operating income (surplus or deficit) from passenger and freight service have for a long time been applied by railways in different parts of the world either as a routine from year to year or only as special investigations on certain occasions. These surplus and deficit calculations were performed according to two different points of view, i. e. firstly in the form of a retrospective analysis of the expenses for a past year, « the accounting

TABLE 9.

	Road A	Road B
	crowns, thousands	
Actual revenues from passenger service	310.9	179.2
Actual revenues from freight service	195.2	146.4
Actual total expenses	483.0	392.1
An *increase* of *passenger* service by 25 % will cause :		
Additional revenues, amounting to	77.2	44.8
Additional expenses, amounting to	10.4	4.4
An additional *net*-revenue, amounting to	66.8	40.4
An *increase* of *freight* service by 25 % will cause :		
Additional revenues, amounting to	48.8	36.6
Additional expenses, amounting to	27.8	26.5
An additional *net*-revenue, amounting to	21.0	10.1
A *simultaneous increase* of both passenger and freight service by 25 % will cause :		
Additional revenues, amounting to	126.5	81.4
Additional expenses, amounting to	37.3	35.7
An additional *net*-revenue, amounting to	89.2	45.7

method », secondly in the form of a prospective estimation of future expenses and revenues, « the alternative budget method ».

3. As to the accounting method one can distinguish two lines of development, firstly one more schematic that is mainly confined to distributing the expenses between passenger and freight traffic only, secondly a more detailed accounting analysis according to which a subtle division between various traffic branches, etc., takes place.

In an enterprise with so complicated production conditions like a railway it is necessary to put well-defined questions with regard to all cost calculations, if these should be useful for practical action. First with a well-defined acting alternative as a basis it will be possible to get a definition of the costs and revenues of this acting alternative.

Therefore, in practical business policy, when it is a matter of choosing between several possible alternatives of action, profit and loss statements according to the accounting method cannot give any direct indication for an economically rational choice. In order to make the economic consequences clear, and thus facilitate a choice between different possible alternatives of action, concerning price policy as well as production and investment policy, the calculation method in part IV, called « the alternative budget method » or « profitability estimations », must be used instead.

4. Even though such profit and loss statements prepared by the accounting method are not directly applicable when it is a matter of choosing between different economic alternatives of action in practical business policy, they may nevertheless be of value in judging the *development* of expenses and revenues of different branches of business and can, when made in an

appropriate way and put together for a sequence of years, serve as a guide in the work of increasing the efficiency of the business.

5. The situations that the administration of the enterprise is confronted with, if investments, tariffs, train schedules etc.,, are concerned, and for which the enterprise in its activity needs guiding by calculations, are so different, so heterogeneous, with regard to the various acting alternatives that the management of the enterprise can make, that the calculations in their turn become very various, in order to correspond to what is economically important in the various situations. Only by defining the calculation situation itself and the alternatives that can be chosen by the administration of the enterprise, one can get a clearly defined conception of the costs. These will then be defined with regard to the acting alternatives between which it may be chosen. The costs and revenues will then express the economic consequences of choosing a certain alternative. Every calculation is, therefore, a comparison between different ways of acting in a certain given situation.

Characteristic of these profit calculations, is the fact that they give an answer to the question, what changes are likely to happen in the expenses, revenues and net-revenues of the enterprise, if a certain change is made in e. g. operation plans, investment plans, pricing policies. The terms relevant for these calculations are thus additional (incremental) and subtractional (decremental) expenses and revenues.

By such shaping of the calculation problem, i. e. with regard to the changes in expenses and revenues in consequence of a certain alternative business plan, one gets rid of the cost and revenue allocations, questionable in many cases, which to a high degree are characteristic of traditional accounting. As the object of the calculation is in every case a special business plan, all differences in costs and revenues between two rival alternatives become *separable* (additional, subtractional) costs and revenues to the plan under study and no fixed, common or joint costs or revenues need to be allocated, if this special business plan is compared with another business plan which is used as a « reference » alternative.

6. Provided the aim of the business activity is to obtain a maximum net-revenue, the general profitability criterion can be stated in the following way. Each business-political measure (changes in rates and fares, of quality with regard to services sold, changes in the size of plants, etc.) is profitable for the enterprise as a whole if there results an increase of the total net-revenues of the enterprise, from the measure in question.

Surplus and deficit calculations for different classes of traffic according to the accounting method, which to a very great extent include allocated common and constant costs, tell nothing about the profitability of the different classes of traffic. Thus a deficit according to a calculation of the above mentioned type need not mean that a withdrawal of the class of traffic in question will increase the profits of the whole enterprise, but only that the class of traffic in question does not contribute to the common costs of the traffic in the same proportion as the classes of traffic which allow a surplus. On the other hand, the revenues of the class of traffic in question may, in spite of this deficit, be considerably greater than the subtractional costs, which would be saved if this class of traffic were discontinued, for which reason the class of traffic in question actually contributes towards an increase of the profits of the enterprise to the extent that these revenues exceed these subtractional costs. Therefore, it pays to retain such classes of traffic as long as they make at least some contribution to the covering of the common and constant costs of production.

In part VI some examples are given how one can prepare the profitability estimations, necessary as a guide for a rational business policy.

7. The present situation as regards cost and revenue analysis of different classes of traffic, etc., is made clear by the answers from various administrations consulted. Annual statistical statements according to the accounting method, showing the calcul-

ated profit or loss on the working of passenger and freight service are prepared only by a minority of the railways concerned.

Most of the other administrations consulted gave information that they do not prepare such profit and loss statements on a yearly basis, but that on certain occasions special studies are made to determine the results of particular services — freight, passenger or any other of the other services related — and special lines of the railway system.

As to the reasons of the introduction of such profit and loss statements of various classes of traffic, it seems that most administrations originally evolved these statements for the purpose of supplying information, considered to be of value as a guide for fixing the general level of rates and fares and controlling the general efficiency of operation in the different classes of traffic etc. The importance of these statements seems, however, as time goes on, to have changed from the final results about profits and losses to the cost and revenue analysis, implied in the preparing of these statements, and many administrations nowadays use them primarily as a basis for conducting special inquiries into various phases of railway working (efficiency analysis). Often the profit and loss statements are also used as a general indicator, that facilitates the determination whether further studies should be made or not, concerning e. g. applications for partial or entire abandonment of operations on certain sections of lines, withdrawal of certain trains and other measures for achieving economy in operation.

***

APPENDIX.

ORDER.

At a Session of the INTERSTATE COMMERCE COMMISSION, Division 4, held at its office in Washington, D. C., on the 11th day of November, A. D. 1935.

In the matter of rules governing the separation of operating expenses, taxes, equipment rents, and joint facility rents between freight service and passenger service on large steam railways.

It is ordered, That :

1. Effective as of January 1, 1936, and thereafter until otherwise ordered, every class I steam railway shall classify each of its various items of disbursement relating to operating expenses, railways taxes, equipment rents, and joint facility rents according to the relation which such item bears to the freight service and to the passenger and allied services of the carrier. Each such item shall have its character appropriately indicated on the carrier's records according to its relation (*a*) solely to freight service, or (*b*) solely to passenger and allied services, or (*c*) in common to both freight service and passenger and allied services, or (*d*) to neither freight service or passenger and alllied services. The results of such classification shall be shown in the annual or other reports made by each such carrier to the Interstate Commerce Commission, as may be indicated in forms adopted therefor. Similar analysis shall be made of every journal entry representing a charge or credit to the above-named accounts and the results of such analysis shall be appropriately indicated on the carrier's records;

2. The operating expenses, railway taxes, equipment rents, and joint facility rents common to both freight service and passenger and allied services shall be apportioned between the two classes of service in accordance with the annexed " Rules Governing the Separation of Operating Expenses, Railway Taxes, Equipment Rents, and Joint Facility Rents, Between Freight Service and Passenger Service on Large Steam Railways, Revised Issue », which are hereby approved and made a part hereof; and the result of such apportionment shall be shown in detail for the various primary accounts in the annual or other reports of each such carrier to the Interstate Commerce Commission as may be indicated in forms adopted therefor; and

3. The order of this Commission relating to the separation of operating expenses and issued under date of December 1, 1919, shall cease to have effect after December 31, 1935.

By the Commission, Division 4.

(SEAL.)

George B. McGINTY,
Secretary.

Rules governing the separation of railway operating expenses, taxes, equipment rents, and joint facility rents between freight service and passenger service.

It is expected that carriers will first assign to freight service or to passenger service, including allied services, the expenses that are directly or naturally assignable and that

this direct assignment will be carried to the fullest extent that is practicable, except as stated below, without undue increase in accounting expense. The methods indicated under the various accounts are for dividing the common expenses.

The separation should, as far as practicable, be made by operating or accounting divisions, and the aggregate of the divisional separations reported for the year.

I. — Maintenance of way and structures.

201. *Superintendence.*

Apportion common expenses according to proportions of accounts 202 to 273, inclusive, excluding common expenses in accounts 247-248.

202-226. *Track expenses, etc.*

It is essential that expenses of all tracks which are maintained by respondent be separated into the following classes :

1. Yards where separate switching services are maintained, including classification, house, team, industry, and other tracks switched by yard locomotives. Running tracks regularly used by road trains, passing tracks, and all turnouts from those tracks to clearance points should be excluded. It is essential that maintenance expenses of yard tracks be kept distinct from those of other tracks. Expenses of exclusively freight or passenger yards should be directly assigned. Expenses of yards used in common by freight and passenger services should be apportioned on the basis of the respective switching locomotive-hours in the common yards.
2. Station, team, industry, and other switching tracks for which no separate switching service is maintained. The expenses of these tracks should either be kept distinct or estimated by respondent on the basis of its experience. Assign the expenses directly as far as practicable. If any tracks are used in common by both freight and passenger services, expense may be assigned to that service which makes the most use of them.
3. Running tracks, passing tracks, crossovers, etc., including turnouts from those tracks to clearance points. The expenses of these tracks (obtained by subtracting the expenses of tracks in classes (1) and (2) from the total track maintenance) should be directly assigned to freight and passenger services, respectively, to the extent they are used exclusively by one service. The expenses of tracks used in common by both services should be apportioned on the basis of gross ton-miles (including locomotive ton-miles) handled over those common tracks in the respective services. The gross ton-miles of freight service should be taken from carrier's records; those of passenger service should be estimated on the basis of carrier's experience and include loads in tenders, mail, baggage, express, and passenger cars. Use average weight of 150 pounds per passenger.

227-228. *Station and office buildings.*

Assign directly, as far as practicable, and apportion the unassigned remainder on the basis of the directly assigned expenses in this account, if those direct expenses are more than 50 percent of the total charges to this account for the system. Unless that is the case, the common expenses should be apportioned on the basis of special test.

229-230. *Roadway buildings.*

Apportion common expenses according to proportions of accounts 202-226.

231-234. *Water and fuel stations.*

Apportion common expenses according to proportions of quantities of fuel (equated to coal tonnage basis) charged to accounts 382 and 394 taken together, after deducting quantities issued from fuel stations used exclusively by one service.

235-236. *Shops and enginehouses.*

Apportion common expenses of shops according to proportions of accounts 308, 311, 314, 317, 323 and 326, excluding common expenses in account 326; of engine houses according to proportions of accounts 388 and 400.

237-246. *Grain elevators, storage warehouses, etc.*

Assign directly or apportion according to facts in individual instances.

247-248. *Telegraph and telephone lines.*

Apportion common expenses on basis of accounts 201, 301, 351, 371 and 372 taken together.

Note. — As accounts 451 and 452 are apportioned on the basis of proportion established for accounts 201 to 446, inclusive, they are not included here as bases for apportioning accounts 247-248.

249-250. *Signals and interlockers.*

Apportion common expenses on the basis of transportation service train hours, including train switching hours.

251-266. *Power plants, etc.*

Assign according to the facts in individual instances.

267-273. *Paving, roadway machines, etc.*

Apportion common expenses according to proportions of accounts 202 to 226.

274-277. *Injuries to persons.*

When not determined by the particulars in individual instances, these expenses should be apportioned according to proportions of accounts 202 to 273, inclusive, excluding common expenses in accounts 247 and 248.

278-279. *Maintaining joint tracks, etc.*

Joint facility debits should, as far as practicable, be treated on appropriate bases according to the use made of the joint facilities by the debtor carrier, regardless of the nature of their use by other carriers. The creditor carrier should apportion the credits on the basis of accounts 202-273, inclusive, excluding common expenses in accounts 247 and 248.

II. — Maintenance of equipment.

301. *Superintendence.*

Apportion common expenses according to freight and passenger proportions of the aggregate of all primary accounts in General Account II, Maintenance of Equipment, omitting common expenses in accounts 328-335, inclusive, and the total of accounts 336-337.

302-303. *Shop machinery.*

Apportion common expenses according to proportions of accounts 308, 311, 314, 317, 323 and 326 combined.

304-307. *Power plants.*

Apportion common expenses on basis of power used.

308. *Steam locomotives-repairs.*

The division should, preferably, be actual — that is, the repairs of road locomotives assigned exclusively to passenger service should be kept distinct from repairs of road locomotives assigned exclusively to freight service. In cases in which locomotives are not run exclusively in one service or the other, the repairs of each locomotive, or class of locomotive, should be divided according to the mileage of the individual locomotive or class.

The annual reports will provide for subdividing account 308 between road and yard.

Repairs of locomotives in yard service should be divided according to the freight and passenger yard switching locomotive-hours.

Two alternate methods for dividing steam locomotive repairs between services are indicated below.

1. Where the cost of heavy shop repairs is kept by individual locomotives, and the cost of running repairs is kept by classes of locomotives, the former should be apportioned between freight, passenger, and yard services on the basis of the run-out miles of the individual locomotive since the previous shopping, and the latter apportioned between such services on the basis of the miles run by the respective classes of locomotives in each service.
2. Where record is not kept of repairs by individual locomotives or classes of locomotives, these expenses should be distributed between services on the basis of locomotive ton-miles or locomotive tractive effort ton-miles compiled separately for (*a*) road freight service, including train switching; (*b*) road passenger service; (*c*) yard service — freight; and

(*d*) yard service — passenger. Locomotive-tons should be determined for each class of locomotive, comprising the weight of the locomotive in working order, plus weight of the empty tender, plus 65 % of the net weight of the fuel and water when tender is loaded to capacity. Locomotive ton-miles should be computed by multiplying the average tons for each class of locomotive, as above determined, by the number of miles run by each class of locomotive in the respective services (road freight, road passenger, yard freight, and yard passenger).

311. *Other locomotives-repairs.*

Treat in accordance with the methods used for account 308.

314. *Freight-traincars-repairs.*

Assign directly.

317. *Passenger-traincars- repairs.*

Assign directly.

323. *Floating equipment-repairs.*

Apportion according to use made of the floating equipment.

326. *Work equipment-repairs.*

Apportion common expenses according to proportions of accounts 202 to 273, omitting common expenses in accounts 247-248.

328. *Miscellaneous equipment-repairs.*

Apportion common expenses according to percentages used to divide common expenses of accounts 201, 301 and 371.

329. *Equipment retirements.*

Observe tenor of directions under accounts 208 to 328.

330. *Extraordinary retirements-equipment.*

Assign directly.

331. *Equipment depreciation.*

Observe tenor of directions under accounts 308 to 328.

332-335. *Injuries to persons; insurance; stationery and printing; and other expenses.*

Apportion common expenses according to percentages used to divide common expenses of account 301.

336-337. *Joint equipment at terminals.*

Joint equipment charges should as far as practicable be treated on appropriate basis according to the use made of the equipment by the debtor carrier, regardless of the use by other carriers. Creditor carrier should apportion the credits on the basis of account 301.

III. — Traffic expenses.

351-359. *Superintendence; outside agencies; advertising; traffic associations; fast freight lines; industrial and immigration bureaus; insurance; stationery and printing; and other expenses.*

Assign directly, as far as practicable, and apportion the unassigned remainder on the basis of the directly assigned expenses in this general account, other than advertising expense.

IV. — Transportation-Rail line.

371. *Superintendence.*

Apportion common expenses according to freight and passenger proportions of the aggregate of all primary accounts in General Account IV, Transportation-Rail Line, omitting the total expenses in accounts 390-391 and 412-413, inclusive, and common expenses in accounts 407, 410 and 411.

372. *Dispatching trains.*

Apportion common expenses on the basis of transportation service train hours, including train switching hours.

373. *Station employees.*

Assign directly, as far as practicable, and apportion the unassigned remainder on the basis of the directly assigned expenses in this account, if those direct expenses are more than 50 percent of the total charges to this account for the system. Unless that is the case the common expenses should be apportioned on the basis of special test.

374. *Weighing, inspection, etc.*

Assign directly.

375. *Coal and ore wharves.*

Assign directly.

376. *Station supplies and expenses.*

Assign directly, as far as practicable, and

apportion the unassigned remainder on the basis of the directly assigned expenses in this account, if those direct expenses are more than 50 percent of the total charges to this account for the system. Unless that is the case the common expenses should be apportioned on the basis of special test.

377-389. *Yardmasters and yard clerks; yard conductors and brakeman; yard switch and signal tenders; yard enginemen; yard motormen; fuel for yard locomotives; yard switching power produced; yard switching power purchased; water for yard locomotives; lubricants for yard locomotives; other supplies for yard locomotives; engine house expenses-yard; yard supplies and expenses.*

Assign directly, as far as practicable, apportioning the unassigned remainder in the common yards operated by steam locomotives in accordance with the switching locomotive-hours in those yards, and the unassigned remainder in the common yards operated by other locomotives in accordance with the switching locomotive-hours in those yards.

392-393. *Train enginemen and train motormen.*

Assign directly, as far as practicable. Apportion common expenses on the basis of the direct assignments.

394. *Train fuel.*

Assign directly, as far as practicable. Apportion common expenses on the basis of the direct assignment.

395-396. *Train power produced and purchased.*

Assign directly, as far as practicable. Apportion common expenses on the basis of the direct assignment.

397. *Water for train locomotives.*

Apportion common expenses on the basis of the equated net tons of fuel consumed by steam locomotives in freight-train and passenger-train services, respectively.

398-399. *Lubricants and other supplies for train locomotives.*

Observe tenor of directions under accounds 392-393.

400. *Enginehouse expenses-train.*

Expenses at each enginehouse should be divided according to the number of engines handled for each service. Where various classes of engines differ considerably in expense of handling at an enginehouse, an arbitrary should be adopted representing such variation and the number of engines handled modified accordingly.

401-402. *Trainmen and train supplies and expenses.*

Observe tenor of directions under accounts 392-393.

403. *Operating sleeping-cars.*

Assign to passenger.

404-405. *Signal and interlocker operation; crossing protection.*

Apportion common expenses on the basis of transportation service train hours, including train switching hours.

406. *Drawbridge operation.*

Apportion common expenses on the basis of train hours of the particular operating division on which the bridge is located.

407. *Telegraph and telephone operation.*

Apportion common expenses on the basis of charges to accounts 201, 301, 351, 371 and 372 taken together.

Note. — As accounts 451 and 452 are apportioned on the basis of proportions established for accounts 201 to 446, inclusive, they are not included here as bases for apportioning this account.

408. *Operating floating equipment.*

Apportion common expenses according to the use made of the floating equipment.

409. *Express service.*

Assign to passenger.

410. *Stationery and printing.*

Apportion common expenses according to percentages used to divide common expenses of account 371.

411. *Other expenses.*

Apportion common expenses according to percentage used to divide common expenses of account 371.

390-391 *and* 412-413. *Operating joint yards, terminals, tracks and facilities.*

Joint facilities should as far as practicable be treated on appropriate bases according to the use made of the facilities by the debtor carrier, regardless of the use by other carriers. Creditor carrier should apportion the total of account 391 on the basis of accounts 377-389, inclusive, and total of account 413 on the basis of accounts 392 to 402, inclusive.

414-417. *Insurance, clearing wrecks, and damage to property.*

Assign directly, as far as practicable. Apportion unassigned remainder on the basis of the directly assigned expenses.

417. *Loss and damage-freight.*

Assign to freight.

419. *Loss and damage-baggage.*

Assign to passenger.

420. *Injuries to persons.*

Observe tenor of directions for account 415.

V. — Transportation-water line.

Assign directly as far as practicable. Apportion remainder on appropriate units according to local conditions.

VI. — Miscellaneous operations.

Observe tenor of directions under General Account V, Transportation-Water Line.

VII. — General expenses.

Assign directly, as far as practicable, and apportion remainder according to proportions of accounts 201 to 446.

VIII. — Transportation for investment-Cr.

The method of deciding upon the amount of this credit will determine the freight and the passenger proportion.

Taxes, equipment rents, and joint facility rents.

503 and 536. *Hire of freight cars.*

Charge directly to freight service.

504 and 537. *Locomotive rents.*

Debtor carrier should assign direct. Creditor carrier should assign according to type of locomotive rented.

505 *and* 538. *Rents of passenger-train cars.*

Assign direct.

506 *and* 539. *Rents of floating equipment*

Debtor carrier should assign direct. Creditor carrier should assign according to type of equipment rented.

507 *and* 540. *Rents of work equipment.*

Apportion in accordance with rules for treating account 326.

508. *Joint facility rent income.*

Allocate directly as far as practicable. Apportion common expenses on basis of accounts 279, 337, 391 and 413 combined.

532. *Railway tax accruals.*

Apportion income taxes in accordance with separation of net railway operating income before deducting Federal and State income taxes. If result for one service upon that basis is a deficit, assign income tax to the other service showing an income.

Apportion other taxes on the basis of separation of total operating expenses.

533. *Uncollectible railway revenues.*

Assign direct.

541. *Joint facility rents-debit.*

Allocate directly as far as practicable. Assign common expenses on the basis of use.

Charges and credits between services.

Carriers in making apportionments under the preceding rules should not, until further notice, make any allowance for the credit that should be given to the freight service for work performed (such as carrying company fuel) for the passenger service and *vice versa*.

[656 .212 .5]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

15th. SESSION (ROME, 1950).

QUESTION III.

New technical methods adopted for the design and construction of large marshalling yards.

Lay-out and equipment :

Side and importance of siding groups ;
Lay-out of connections at entrance to groups ;
Longitudinal and cross sections ;
Braking installations (Retarders) ;
Control of point (switch) operation ;
Telecommunications ;
Lighting ;
Staff buildings, etc.

REPORT

(America (North and South), Burma, China, Egypt, Great Britain and North Ireland, Dominions, Protectorates and Colonies, India, Iran, Iraq, Malay States and Pakistan).

by J. I. Campbell, M. I. C. E.,
Civil Engineer, Eastern Region, British Railways,

and J. W. Watkins, D. S. O., M. C., M. Inst. T.,
Operating Superintendent, London Midland Region, British Railways.

INTRODUCTION.

The last occasion when the subject of « Marshalling Yards » came before Congress was at the XIth Session at Madrid in 1930 under the heading of « Methods to be used in marshalling yards to control the speed of vehicles being shunted and to ensure that they travel on to the lines in the various groups of sidings » and it was dealt with in Section Three — « WORKING ». The summaries adopted at the 1930 Congress, though mainly from the operating or working angle, form a useful background from which to approach the subject on this occasion.

The present question is under Section One — « WAY and WORKS » and although it specifically mentions « New Technical » methods, we are interpreting it as including any developments adopted since 1930 in the layout and equipment of marshalling yards.

As is customary, a questionnaire on the present subject has been sent through the medium of the Secretariat to all the affiliated Administrations, and we had the privilege of agreeing the questionnaire with the other Reporters on this subject with the object of facilitating the conclusions to be arrived at eventually at the Rome Session. A list of the Administrations in the countries allocated to us is given in Appendix « A » with an indication as to those which were able to furnish replies or not, and those from whom no reply has been received.

The only Administration which submitted replies to all the questions was British Railways through their several Regions. Interesting data was supplied from India but it is disappointing that from the United States of America where the most extensive developments have taken place, the only Administration from which any detailed replies were forthcoming was the Pennsylvania Railroad.

In the circumstances, therefore, and as a report on this subject would be incomplete without some further reference to the considerable number of American yards embodying modern features, we have been obliged to seek information from other sources, for example, the « Railway Age », « Railway Signalling and Communications », the A. R. E. A. « Manual for Railway Engineering » and the A. R. E. A. proceedings.

With regard to the form of questionnaire, we feel that there is a risk, which it would be well to try and avoid in future, of replies becoming limited to answering stereotyped questions, whereas free and frank expression on such an interesting and widespread subject should be sought in addition to furnishing replies to specific points desired for comparative purposes.

The Administrations were requested to name the large yards constructed or modernised since 1930 and to include any on which work is at present being carried out. A list of these yards, with information as to the extent of traffic dealt with, is given in Appendix « B ». They were also asked to furnish plans and profiles of these yards, but it will not be possible to reproduce drawings and gradient sections of all the yards included in Appendix « B », and therefore we have selected the following :—

Fig. 1 HULL Inward, *British Railways* (N. E. Region).

Fig. 2 MOTTRAM, *British Railways* (E. Region).

Fig. 3 TOTON Up, *British Railways* (L. M. Region).

From the wording and the inclusion of the subject under Section I — « Way and Works », it would appear it was the intention that the matter should be considered from the « technical » angle in the sense that this applies to « engineering » in all its branches, civil, mechanical, electrical, signalling and telecommunications.

The subject cannot however be entirely divorced from the « operating » aspect, and although the organisation of a railway differs in the various countries, and may vary between Administrations within one country, the responsibility for working a yard on railways which have a high degree of traffic density, such as in Great Britain, usually devolves upon a separate officer.

Under these conditions the Engineering Departments are the « providers » and the Operating Department the « user », and since the best results are likely to be achieved where the « user » indicates the character of the installation desired, it follows that the Operating Department is closely interested in technical developments which expedite working and reduce operating costs.

Elsewhere before Congress, under Section III, Question VII, is the subject of « Organising methods to be used in large marshalling yards and terminals to reduce to the minimum the cost per wagon shunted » and we do not propose to anticipate the findings of the Reporters thereon.

The features associated with efficient yard operation are so numerous and embrace such items as avoiding delays to trains on adjacent running lines, movement of

train engines in and about yards, reducing double-handling of vehicles, performing the work at the lowest cost in man-power and shunting engine time, eliminating damage and accidents and speeding up traffic, that the Operating Department, through their experienced staff, should indicate their requirements to the Engineering Departments. There should be the closest co-operation between the Operating and Engineering Departments on technical matters in connection with layouts, braking, point operation, signalling, communications, lighting, buildings, etc.

Two words in the title of this subject come to mind namely « design » and « construction ». It needs little knowledge of the layouts of the older yards owned by the various Administrations to appreciate the divergence of opinion and practice in the past, the scope there is for modernisation, and the need for further detailed study and co-operation between the providers and the users of yards.

Difference of opinion arises as to the relative merits of retarder, hump and gravitation yards, and particularly in respect of the economic datum line at which it pays to « mechanise » a hump yard i.e. to provide retarders.

The scope for development depends largely on the conditions prevailing in the country concerned. Where economic and financial considerations are more favourable, where new yards become a necessity, and where the layout is not restricted by site limitations, it is obvious that greater possibilities exist. Clearly in the case of the older-established railway systems, there is likely to be a greater need for modernisation but the major re-construction of existing large yards may not easily be justified financially unless there are appreciable economies which will furnish a reasonable return on the outlay.

In drawing up this report we are as far as practicable following the sectional sub-headings under the title of the main question, and the questionnaire was arranged in the same order.

A. — Site and importance of siding groups.

This section is concerned with the various siding groups which taken together make up the layout of the yard as a whole so as to provide the most expeditious service at the most economical cost. In considering the planning of the yard as a whole, one is confronted with the problem of designing a number of separate units, each having its special functions, and so placed that all operations are progressive and, as far as practicable, unhindered by conflicting movements. Each of these units, whether it consists merely of equipment or a complete track layout, should be designed with a full knowledge of the peak and average demands which are likely to be made upon it, and located to conform with the complete scheme.

It has been generally accepted for a long time that, in principle, large yards should comprise groups of sidings *in sequence* for :

a) Reception of incoming trains.

b) Sorting of vehicles into direction or destination order.

c) Holding made-up trains preparatory to departure.

Other groups are provided, not necessarily in sequence, where the character of the traffic and the requirements of the service necessitate it, for :—

d) Subsidiary shunting.

e) Temporarily holding excess accumulations of vehicles.

f) Repairing defective vehicles.

g) Facilitating connectional and through services, etc.

The provision of all these facilities depends upon space being available, and where not available but could be made so at a cost, the financial aspect has to be taken into consideration. This is particularly the case in Great Britain, where most yards are, or were at the time of their original construction, in the appropriate

situation, and where the enlargement of these yards or the construction of new yards is so often precluded because of the density of the populated areas and the proximity of physical obstacles.

Each marshalling yard constitutes an individual economic operating and engineering problem, and therefore completely standardised types of layout and equipment cannot be applied to a particular site.

Double direction yards.

Information was sought through the questionnaire as to instances where opposing flows of traffic are sorted in one yard. No instances are reported where separate yards have been combined in the interest of economical working.

Of yards reported as having been constructed or modernised since 1930, Naihati (East Indian Railway) is the only one quoted as a double direction yard. From the brief description given it would appear that the yard is laid out as separate « up » and « down » yards for hump shunting but one of those humps, being equipped with retarders and electrically operated switches, is used to sort both up and down traffic.

At North Platte on the Union Pacific Railroad, a large double direction yard was completed in 1948. The eastbound and westbound tracks pass round the perimeter of the site and two receiving and two departure groups are placed side by side at the west and east ends of the site respectively, with one retarder sorting group in the centre of the layout. Fig. 4 indicates diagramatically the plan of this yard.

The advantages of a double direction yard depend upon the total quantity and fluctuation of the traffic, and in designing the layout particular attention should be paid to the avoidance of interference with shunting operations. A maximum number of vehicles for such a yard cannot be prescribed since it must obviously depend upon the general layout, the nature of the traffic, and upon whether the yard is mechanised, hump or flat.

There exist however numerous instances of yards laid out for a normal uni-directional flow, but which have to provide for a minor proportion of traffic whose flow is in the opposite direction. All such instances are usually the outcome of main or branch line configuration and the situation of junctions in relation to the particular yard.

Marshalling groups.

Where a separate group of sidings is necessary for marshalling vehicles in a particular order before a train is despatched, it is generally provided in parallel with the main sorting group, e.g. as at Hull (Inward) yard, see Fig. 1.

One or more such groups may be provided, and the number of individual sidings necessary can only be determined by an analysis of the character of the traffic, the number of places to be served, and the incidence of arriving and departing trains — this latter feature often being the governing consideration on account of main line paths and occupation.

Departure group.

Where the circumstances justify it a separate group of sidings for holding trains preparatory to departure is provided where practicable, and should be sited in sequence beyond the sorting group.

It is reasonable to assume that the main lines in the vicinity of a large yard are fairly heavily occupied, and since the timing of main line trains cannot generally be subordinated to yard operations, occasions arise when sufficient traffic accumulates for a particular outwards train, some time before it can be despatched. In such circumstances the shunting of further traffic which arrives at the yard would be likely to be delayed, thereby impeding yard operations as a whole.

No hard and fast rule can be laid down as to the amount of accommodation for trains which have to call at a yard for purposes other than shunting. Such stops may be necessary for changing locomotives, reliev-

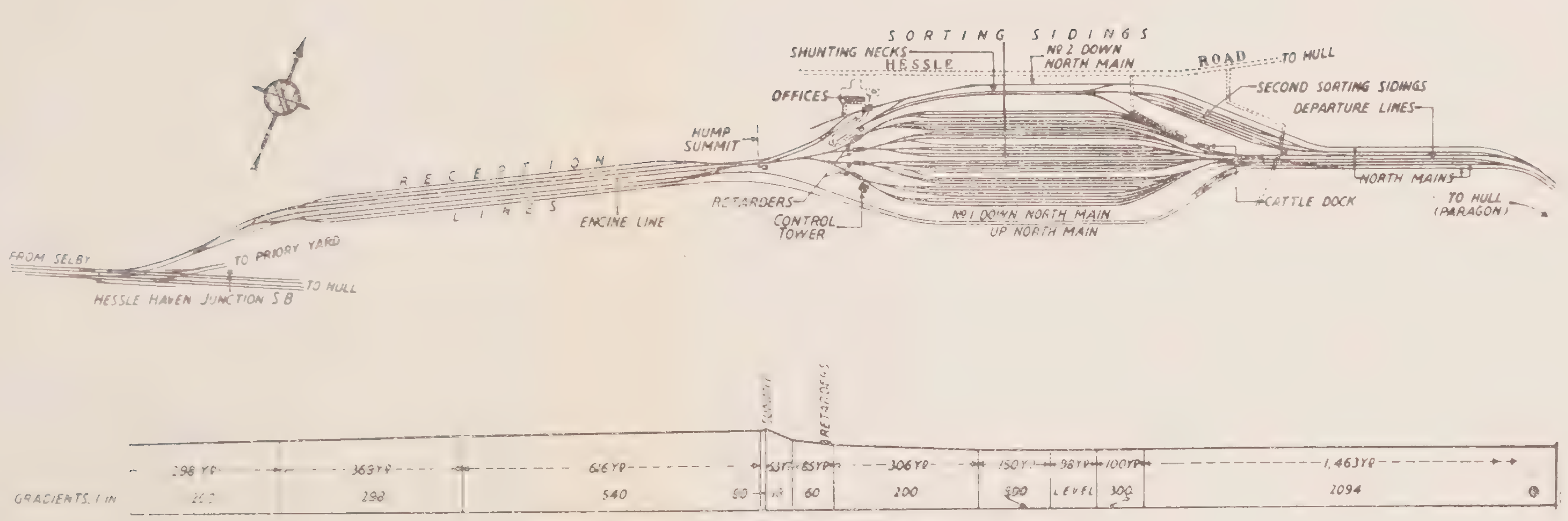


Fig. 1. — Hull Inward yard. — British Railways, N. E. Region.

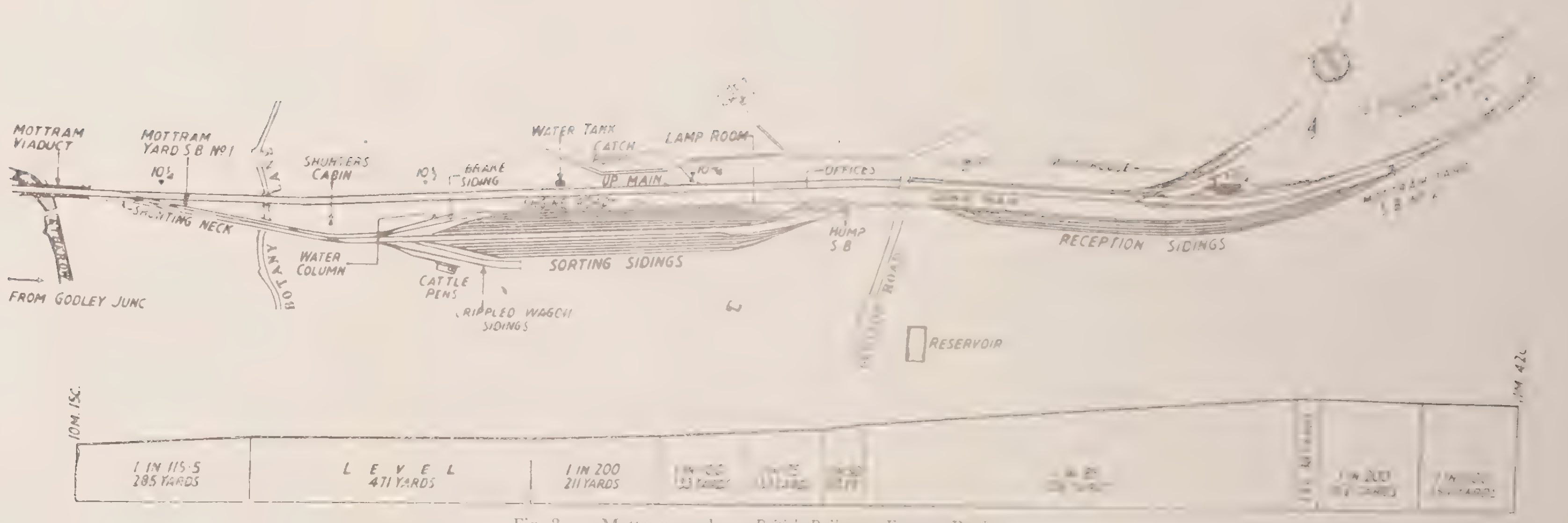
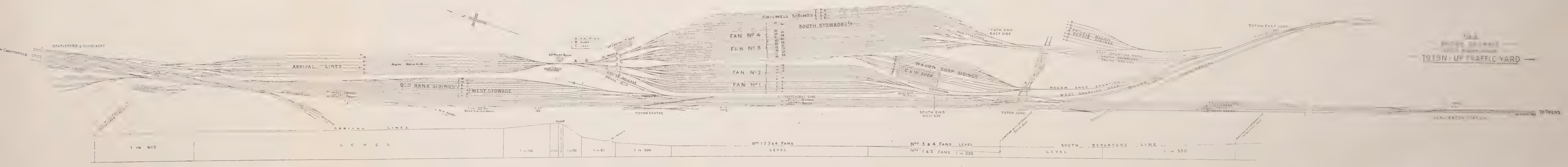
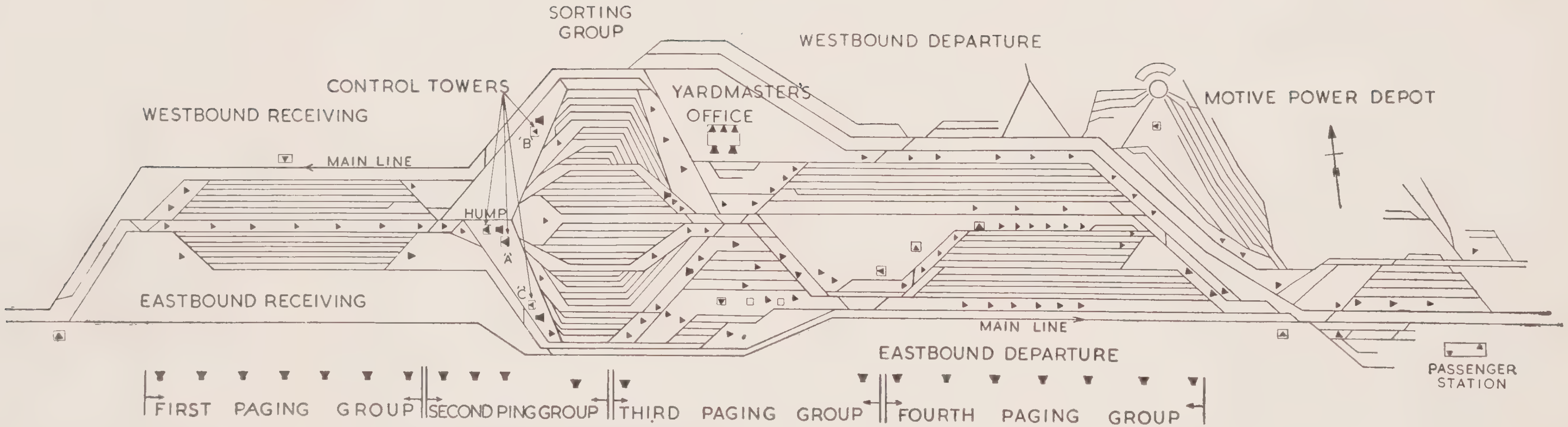
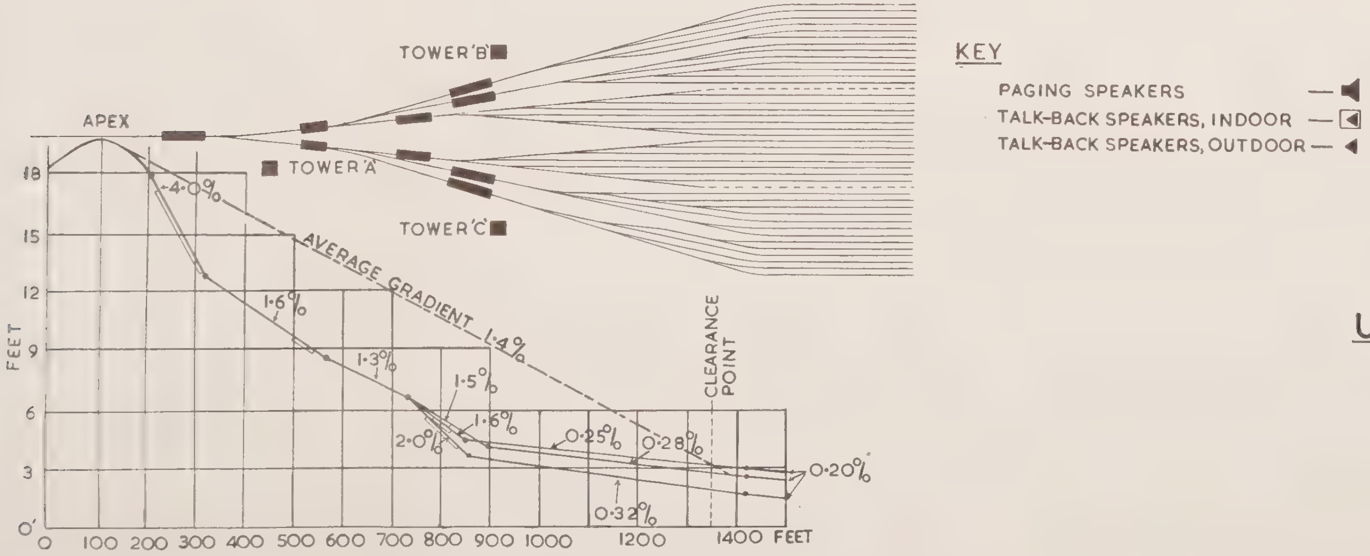


Fig. 2. — Mottram yard. — British Railways, Eastern Region.







NORTH PLATTE YARD

UNION PACIFIC RAILROAD

FIG. 4

ing enginemen and/ or guards, steam engine taking water, routine examination of vehicles or awaiting a forward path over the main line. Clearly such operations should not be carried out with the train occupying a main running line, or on arrival lines or sidings used for trains which have to be broken up as part of the normal yard operations.

The amount of accommodation for such trains must be determined in each instance on merits. Normally it would be sited between the main line and the yard but other factors such as cross-over facilities, location of motive power depot, etc., must be taken into account.

Transfer of through vehicles.

Where there is a considerable amount of traffic to be detached at a yard for attaching to other outgoing trains, and which does not require to be shunted in the ordinary sense, a separate group is provided, as, if operations of this character were extensive, it would be to the detriment of operations if carried out within the yard.

Locomotive and brakevan movements.

For the release of train engines, attaching engines to outgoing trains, and detaching, servicing and attaching brakevans, sequential movement is aimed at so as not to impede yard operations.

In the case of the engines to be liberated from incoming trains, the usual arrangement is a separate lead immediately beyond the point where the arrival lines converge— the lead giving shortest possible access to the Motive Power Depot. A lead for this purpose before the hump is reached, increases the distance (and consequently the time occupied in humping operations) between the leading wagon on a train to be shunted and the hump. Therefore in some instances the engine release line is connected to the humping line immediately beyond the apex. In this connection it should be remembered that in humping a train the speed of propulsion towards the hump is necessarily very low.

With regard to engines arriving to work outgoing trains, a separate running connection off the main line should, if possible, be provided and the « engine arrival » line should be such that it can, if necessary, accommodate one or more engines which have arrived whilst another train is departing.

A spur line is usually provided in the vicinity of the hump to accommodate brakevans while attention is given to cleaning, lamps, etc. Where trains are despatched direct from a sorting siding it is a convenience to be able to shunt a brakevan from such a position on to the rear of the train. Since all trains cannot depart from the sorting group direct, and in some instances have to stand on an outgoing running line or in the departure group, a trailing spur line suitably connected at the outgoing end of the sorting group may be provided. A useful arrangement is to have this brakevan spur on a steep falling gradient, fed with brakevans off incoming trains, and one of which can be gravitated under hand control to the back of a train ready to depart.

Length of Sidings.

The length of reception lines is governed by the maximum permissible train loading on the running lines. This is associated with the class of locomotive employed, the gradients on the route, the capacity of loops, and other limiting operating features. To this capacity expressed in terms of overall length of vehicles must of course be added the length of the longest engine or engines and the brakevan. Some margin over and above the effective capacity should be allowed and an addition of 7 per cent has been suggested by the Indian Railways.

In respect of sorting groups, information varies, some Administrations consider 50 per cent more than the longest departing train, others 25 per cent. Obviously capacity over and above the length of the longest

train should always be provided where practicable. Therefore, a compromise is required in the light of the character of the traffic and bearing in mind that vehicles will not always come to a stand close together.

Appendix « C » gives for yards mentioned in Appendix « B » the number and capacity of the sidings.

Number of Sidings.

Factors to be considered in determining the number of sidings in the respective groups are as under :—

a) *Reception group.*

After taking into account the rate of shunting, for example the number of trains which can be shunted in a given period, according to the type of shunting and the number of shunting engines employed, the number of arrival lines should be sufficient to receive trains off the main line during the period of the day when the density of arriving trains is the greatest. It is important that at no time should running lines be blocked with trains waiting to enter marshalling yards.

b) *Sorting group.*

The number of sorting sidings should be sufficient to permit of at least one siding being allocated to each specific direction or destination, consistent with the volume of traffic offering.

A most important principle to have in mind is to enable trains to be made up complete to the most distant yard or depot possible in order to eliminate further shunting at intermediate points, and to speed up the movement of traffic and vehicle turn-round, and to economise in engine user.

The distance from the hump to the clearance points in the sidings increases with the number of sorting sidings and it is desirable to keep this distance down to the lowest possible limit consistent with easy curvature.

With the balloon type of layout the ideal is to conform to the following series, 2, 4, 8, 16 and 32 sidings. It appears, however, the latter figure is insufficient for the largest yards and 64 would be excessively large. For practical requirements therefore, and to keep the layout of the yard within reasonable proportions, a total figure of 40 sidings in 4 fans of 10 sidings each is probably the limit which can be worked satisfactorily.

c) *Departure group.*

Since this performs the reverse function to the reception lines, similar considerations should apply. There should be sufficient lines to accommodate the number of trains necessary to keep the sorting sidings fluid, and at the same time to hold sufficient trains during peak periods of main line occupation.

d) *Marshalling group.*

This must be determined by local conditions and requirements.

B. — Layout of connections at entrance to groups.

Entrance to reception lines.

A type of facility provided at Hull (Inward) and at Toton (Up) yards is illustrated by the first of two diagrammatic sketches (Fig. 5). The second sketch indicates an alternative layout where space does not permit of the dual facility shewn in the first sketch.

When an engine is sent from the hump to proceed behind another train preparatory to humping, it is despatched via the « run-round » line into a dead-end spur. From this point it can be directed behind the next train to be humped on whichever arrival line it may be standing. The signalling arrangements between the hump and the signal box at the entrance to the yard are thereby simplified. In the first illustration, if a train is entering any of the reception lines 1 to 5, the humping

engine can be placed at the same time behind a train on any of the arrival lines 6 to 11, and vice versa.

The use of the run-round line shewn in both illustrations is confined to the hump engine running light to the entrance end of the reception lines, and for drawing any vehicles out of the sorting group for re-shunting, and these two operations are not normally permitted on any of the reception lines.

be designed so that trains can follow one another over the hump quickly. It is, therefore, necessary that the tracks should converge to the humping line in the shortest possible space. The arrangement of the leads to achieve this will be governed by the number and distance apart of the reception lines.

Where the classification of the sorting sidings is such that vehicles from any train are required to be shunted into any of the

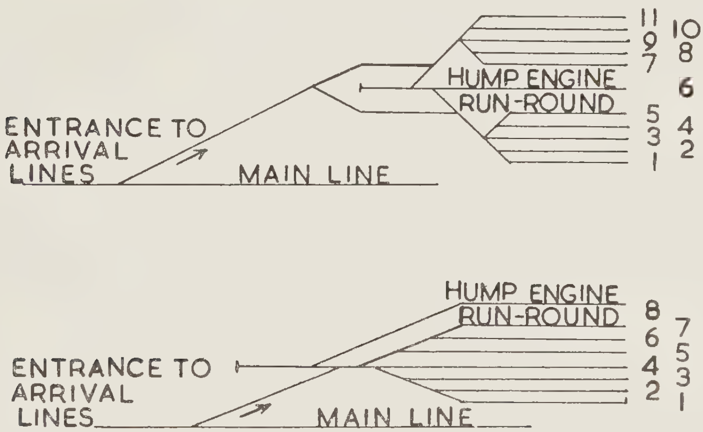


FIG.5 DIAGRAMATIC SKETCHES ILLUSTRATING HUMP ENGINE RUN-ROUND FACILITY

Thus the reception lines are used exclusively for the purpose for which they are intended. Delays to incoming trains are avoided during a run-round operation and humping can be carried on with less interruption than occurs when a hump engine has to run back along the line from which it may have just shunted a train.

Outlet from reception lines.

The general layout of tracks leading to the hump from the reception group should

sidings, there is little or no evidence in support of providing more than one hump line. With two lines over the hump, a scissors cross-over must of necessity be incorporated at some point thus increasing the over-all length of the hump line.

No Administration has reported that two lines are laid over the hump in order to permit maximum continuity of shunting operations. On the contrary, some expressed the opinion that this is not possible unless the yard is worked in two sections in order to avoid conflicting movements.

Hump by-pass.

Hump by-pass facilities exist at some yards for :—

Liberating train engines,

Despatch of trains in the direction of the hump from the sorting sidings,

Receiving trains on to the main reception lines which do not enter at the normal inlet.

Facilities for despatching outgoing trains via entrance to sorting group.

In general it is undesirable to attempt to provide for despatching outgoing trains via the entrance to the main sorting group. It may be that in certain circumstances it is necessary to despatch a train in this manner but any movement which is in a contrary direction to the normal flow of traffic will retard operations generally, apart from gradient and layout considerations.

Therefore, for any double-ended yard « wrong direction » trains should be drawn out via the outgoing end. Obviously, in the case of single-ended yards outgoing trains must depart via the entrance end.

The only example reported of an avoiding line being provided for the purpose of despatching trains in the direction of the hump direct from the sorting sidings occurs at Whitemoor (Down) yard. This is only from one of the outer fans and it is incidental that this line passes in the vicinity of the hump, on account of the position of its outlet to the main lines.

Seasonal humps.

No Administration reported that separate Winter and Summer humps were necessary. The provision of a double hump would be open to the same objections as mentioned in the paragraph respecting two tracks over the hump. There are in Great Britain non-retarder yards where the apex of a hump is raised slightly at the commencement of Winter, since vehicles run more freely in warm weather than in cold. This feature is particularly pronounced where vehicles still have grease axle box lubrication, as in Great Britain, where the preponderence of the former privately owned wagons are still grease lubricated.

In the U. S. A. during cold weather, it is the normal practice to inject hot oil into the boxes immediately before vehicles approach the hump. Oil under pressure is applied at a minimum temperature of 180° F.

Distance between tracks.

The principal factors governing the distance between tracks in the sorting group are :—

a) Incorporation of existing tracks when embodied in a new scheme.

b) Maximum and normal widths of vehicles working into the yard.

c) Safety and duties of staff.

d) Required capacity of yard and area of site available in relation to requirements elsewhere in the marshalling yard.

e) Space for lighting-poles, etc.

f) Space for standards in the case of overhead electrification.

Appendix « C » indicates that the normal distance between centres of adjacent tracks in the sorting group varies from 11′ 2″ to 13′ 2″ for British Railways. At Enola yard, U. S. A. the distance is 12′ 6″.

At Toton (Down) yard and at Enola, existing tracks have been incorporated in the new layout, but most of the other British yards were constructed on clear sites. In the U. S. A., the A. R. E. A. recommendations give a normal spacing of 13′ 0″ but several recent yards have been constructed with 14′ 0″ between track centres.

In respect of item *b*), table I gives information concerning the widths of goods vehicles used by the various Administrations, and sets out the space between them, assuming minimum distance between track centres.

TABLE I.

ADMINISTRATION	Gauge of track Ft. In.	Average length of vehicle Ft.	Width of vehicle: Normal Ft. In.	Width of vehicle: Maximum permitted Ft. In.	Minimum distance between track centres Ft. In.	Space between normal vehicles Ft. In.
British	4—8 ½	21	8—8	9—0 9—3	11—2	2—6
Indian	5—6	25	—	10—6	15—6	—
U. S. A.	4—8 ½	45	10—0 (approx.)	10—2	13—0	3—0

With regard to items *c*) and *d*), it will be appreciated that the minimum spacing of sorting sidings will give the most compact layout of switches leading from the hump and that vehicles will then reach the clearance points in the shortest time and at correct speed. An additional advantage of closer spacing is, of course, that the total capacity and lengths of individual tracks can be increased.

Appendix « C » indicates the provision made for lighting poles, etc. Where wider spacing is adopted this occurs at intervals of 4 to 8 tracks and Hull (Inward) yard is typical in this respect. In the U. S. A. where floodlighting is in general use, it is possible to adopt uniform spacing for all tracks.

For reception and departure groups, there are no replies indicating that the Administrations adopt different spacing. There would seem to be no reason why differentiation should be made between these groups and the sorting group, unless exceptional facilities are provided, as for example at Toton (Up) yard, where additional space has been allowed between alternate reception lines to accommodate humping signals.

For vehicle repair sidings, engine pit lines, etc., wide spacing is provided. The A. R. E. A. recommend that vehicle repair tracks should be spaced at 18 ft. and 24 ft. centres alternately and that paving be provided between the tracks.

Permanent way.

The crossing work in marshalling yards is not usually of special design, and in Great Britain and the U. S. A. simple turnouts with No. 7 ½ or 8 acute crossings are generally used. In India, the crossing standardised for the 5′ 6″ gauge is No. 8 ½. At Toton (Down) retarder yard, however, three-throw turn-outs were adopted for the « jack » points (tertiary leads) on account of site limitations. In the U. S. A., tandem (lapped) leads are laid in on many sites in order to reduce the distance from the apex of the hump to the clearance points in the sorting group.

The installation of three-throw and of tandem leads reduces the distance between the apex and clearance points by approximately 90 ft. and 60 ft. respectively. For example at Willard yard, Baltimore and Ohio Railroad, where lapped leads are provided, the maximum distance between these points is 830 ft. for 32 sorting sidings at 13 ft. centres (see Fig. 6). This dimension includes 115 ft. for an additional retarder before the « king » switches, which would not be required under British conditions. At Hull (Inward) yard, with 30 sorting sidings at 11′ 8″ average centres, the same dimension is 810 ft., the conditions of curvature being similar.

In Great Britain, new 95 lb. B. H. rail and 109 lb. or 113 lb. F. B. rail is laid in the heavily used crossing work, and in

plain line at the head of the sorting group, also at connections to running lines, on the hump, etc. In the yard generally, plain line and crossing work is laid with serviceable rail of weight, length, and quality appropriate to the importance of the track in which it is to be laid and is selected from the stocks available; the weight is generally not less than 75-80 lb. per yard.

new 131 lb. rail is used for the heavily worked crossings and plain line, and new 115 lb. rail is in some cases used for the more lightly worked leads beyond the retarders. Elsewhere in the yard, serviceable rail of approximately 85 lb. to 100 lb. per yard is used. The ballast is normally ash or gravel.

In order to reduce track resistance in the switching area the length of check rail in crossing work should be as short as possible.

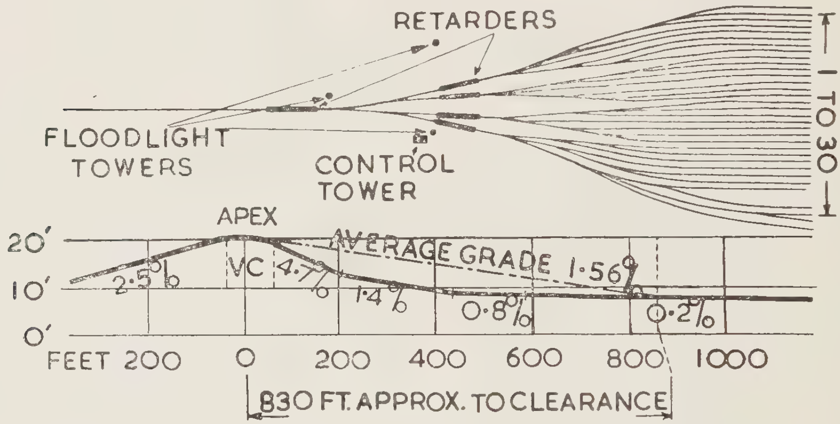


FIG. 6 WILLARD YARD—BALTIMORE & OHIO R.R.

In all point and crossing work timber sleepers are provided. In plain line where there is no need for track circuiting, concrete sleepers (approximately 10″ × 6 1/2″ × 8′ 3″) may be substituted for new timber sleepers. In the sorting group and in lightly used tracks, concrete sleeper blocks are used with full length sleepers at 7′ 6″ intervals, the latter being required to keep the track to gauge.

The ballast in marshalling yards usually consists of engine ashes 12″ deep below the undersides of the sleepers; in track circuited areas, however, small stone or slag ballast retained by precast concrete kerbs is used to provide better drainage.

In the marshalling yards of the U. S. A.

Rail lubricators of standard proprietary types are widely used in the U. S. A., but are only occasionnally fitted in Great Britain. In India they have not been used. It would seem from published American experience that the life of switch blades and of rails on curves is considerably increased by their use, and that improved running of vehicles is obtained. Where, however, engine sand becomes mixed with the grease, an abrasive mixture is produced which may increase wear.

Tests carried out on British Railways (L. M. Region) revealed that the benefits of rail lubrication for the purpose of improving running of vehicles from a hump

round the sharper curves in a sorting group were negatived to a considerable degree in cases where engines had to return over the rising gradient with heavy loads.

Earthworks and Drainage.

The introduction of new types of excavation and earth moving equipment has greatly facilitated the construction of marshalling yards. The use of heavy plant on the earthworks has the advantage of consolidating the site, and for this purpose the routing of the earth moving equipment should receive careful consideration. Sheeps foot rollers are used when consolidation by normal means is not sufficient.

The unloading of ballast and tracklaying are also operations which can, on many sites, be fitted into the programme of mechanised work. Track materials can be transported in prefabricated sections, and ballast unloaded from drop-side vehicles by « pusher » type unloading machines.

To prevent settlement of the hump at Toton (Down) yard, the track is supported on precast concrete units embedded in the ballast 12″ below sleeper bottom.

In British yards, settlement of the retarders themselves is not a problem as they are supported on a concrete foundation. In the U. S. A., the types of retarder used are not usually provided with a foundation other than an adequate depth of stone ballast, but in some cases selected filling material, such as rock, is provided under the retarders and carried down with adequate drainage to a firm bed below the original ground level.

At Argentine yard (Santa Fe Railroad) the hump, having been unavoidably constructed with poor materials, was subsequently protected against percolation of surface water by a limestone-sand-asphalte mixture varying in thickness from 4″ under the sleepers to 2″ between the tracks.

In the body of the yard, British practice is to provide pipe rubble-filled drains between the tracks, the formation being graded to fall to the drains. Salt glazed earthenware pipes of 9″ minimum diameter are laid with open joints on a concrete bed, and are usually protected against choking or fracture by a layer of fine gravel over the pipe. Inspection pits are generally spaced at approximately every 100 ft. to facilitate maintenance. At the Whitemoor yards longitudinal drains are provided between every 6th track and at Toton (Up) yard between the fans with cross drains as necessary.

In the U. S. A., perforated and corrugated types of steel pipe are widely used for surface water drains in marshalling yards. French drains have been adopted in some yards.

Most Administrations emphasise the importance of having a good depth of porous ballast over the whole yard, especially in the area at the head of the sorting group where there may be track circuits, and upon the hump.

C. — Longitudinal and cross-sections.

Continuous falling gradients.

The instances where large yards are operated entirely on the gravitational principle are comparatively few, because they depend to a large extent upon the levels at the entrance and outgoing ends respectively approximating to what is required to give suitable falling gradient sections throughout the yard. Such yards usually occur where the site conforms to these requirements or can readily be made to do so. An older well known example is Edge Hill (B. R., L. M. Region) with more modern ones at Crofton (B. R., L. M. Region) and Mottram (B. R., E. Region).

No special arrangements for braking are reported and under British conditions the trains are held on the falling gradient of the reception lines by applying the handbrakes (with which all vehicles are fitted) on a few of the vehicles at the lower end. The « cuts » are released by lifting the handbrakes thereon and applying the brakes to a few of the succeeding vehicles

which are then uncoupled into « cuts » as necessary. This process of applying and releasing handbrakes alternately on the successive « cuts » is pursued until the whole of the train has been shunted.

Advantages claimed for a completely gravitational system are :—

a) engines are not required for propelling vehicles over a hump,

b) less necessity for the employment of engine power to close vehicles together in the sorting sidings.

Against this are the following disadvantages :—

c) extra care has to be taken to ensure that vehicles do not get out of control and over-run at the outgoing end,

d) the shunting capacity is less than in the case of a hump yard, since a high rate of motion of vehicles cannot be undertaken,

e) as every cut has to be hand braked at some stage there is a risk of savings in engine power being negatived by the necessity for additional shunting staff acting as brakesmen if the number of wagons is considerable and the gradient in any way excessive.

Apart from Mottram, plan and gradient section of which is given in Fig. 2, with traffic and other details in appendices « B » and « C », no completely gravitational yard is reported as having been constructed in the last 20 years.

When a new yard is required, it is desirable to consider the possibilities of employing wholly gravitational methods but a decision will depend upon the suitability or otherwise of the levels at the extremities of the yard and whether the amount of traffic is likely to be capable of being handled by a reasonably economical number of staff.

Hump yards, general longitudinal profile.

The choice of a suitable site for a hump yard is not so restricted as in the case of a gravity yard, but it is essential, if undesirable gradients are to be avoided on the reception and departure lines, that the difference in levels between the inlet and outlet should be within a certain limit which will depend upon the total length of the marshalling yard and the limiting gradients within the groups.

In a hump retarder yard, the difference in level between the apex of the hump and the lowest level of the sorting group is normally 12 to 18 ft. and easy gradients are required on the reception and departure tracks.

In practice, however, it is not possible to make these levels a governing factor in the siting of a hump yard, and in order to gain the elevation necessary for providing a hump, gradients may be necessary on the reception and departure tracks.

For Toton (Up) yard, the plan and profile of which is given in Fig. 3, the differences in level between the inlet and the two outlets are approximately 12 ft. and 6 ft. respectively, and the difference between the hump apex and the lowest level of the sorting sidings is approximately 12 ft.

For Hull (Inward) yard, Fig. 1, the difference in level between inlet and outlet is approximately 3 ft. and the difference in level between the hump apex and the sorting sidings is approximately 18 ft.

It has been possible for the reception lines at Toton (Up) yard to be constructed on the level, whereas at Hull an average rising gradient of 1 in 270 (.37 %) is necessary.

For reception lines, the gradients in British yards are governed by the following considerations :—

a) Trains arriving (with bearings warm and therefore free running) should be able to stand whilst waiting to be humped with no more than the van brakes applied. The application of vehicle brakes entails extra labour and delay.

b) In order that humping speeds can be controlled and cuts readily uncoupled, the vehicle buffers must be kept in contact.

Thic is normally provided for by means of a short steep rise approaching the hump.

For departure lines, where provided, the gradient generally depends upon site conditions, but if possible a slight fall in gradient towards the outlet is desirable in order to facilitate the starting of outgoing trains.

The gradients of reception and departure lines may require local variation, especially if existing works are incorporated in the scheme, or where structures, such as bridges, affect the general profile.

In the sorting sidings the gradients between the clearance points at either end should be non-accelerating for good running vehicles under favourable conditions. In Britain a figure of 1 in 200 (.50 %) has been incorporated in the profile of the most recent retarder yards, but in the U. S. A. where vehicles are heavier and easier running a gradient of 1 in 500 (.20 %) is generally used. In both countries the gradient is reversed or levelled out towards the end of each sorting siding.

At Hull (Inward) yard, a rising gradient of 1 in 300 (.33 %) for 300 ft. at the outlet end is provided and at Toton (Up) yard there is a considerable length of level track.

For groups required for « marshalling » or other purposes, examples of which are indicated on the plans of Toton (Up) and Hull (Inward) yards, the sidings are level. Marshalling is carried out in some instances at the departure ends of sorting sidings. The ideal arrangement where it could be justified by the amount of traffic would, however, be to provide a subsidiary hump.

The A. R. E. A. manual states that marshalling can be economically carried out by flat shunting on the departure lines (no doubt at the same time as the very long trains operated in the U. S. A. are « doubled up »). It recommends, however, that sufficient sorting sidings should be provided in order to reduce the amount of marshalling, and as automatic couplers are used, this policy would result in a considerable saving of time, and less occupation of the yard outlet.

When considering the general longitudinal profile of a marshalling yard scheme, a very important factor governing the choice of site is the desirability of equalising the excavation and filling volumes. The cost is heavy, and delay is incurred with the progress of construction work, if the filling from borrow pits, etc., or surplus spoil, is hauled for distances beyond the economic range of the earth moving equipment.

Hump apex to clearance points.

Appendix « C » sets out the main particulars which have been submitted by the Administrations for the longitudinal profile of humps and Fig. 7 gives further inform-

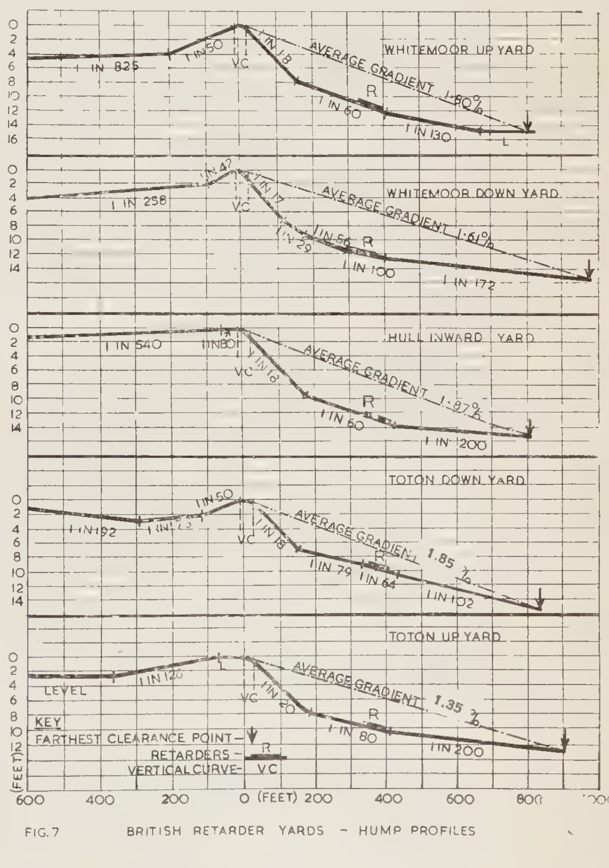


FIG. 7 BRITISH RETARDER YARDS – HUMP PROFILES

ation as regards the varying gradients which constitute the hump profiles at British retarder yards. The design of the hump profile depends in the first instance upon the number of sorting sidings and upon their spacing and radius of curvature. Appendix « C » therefore includes these particulars for the various yards so that the compactness of each layout, as expressed by the distance from the hump apex to the clearance point, can be assessed.

It would seem that the recent tendency in British retarder yards is to design the layout at the head of the sorting group with curves and crossings normally used in sidings and with rather less emphasis on the provision of a compact switching area.

At Enola yard, U. S. A., Fig. 8, site limitations have apparently prevented a symmetrical layout being used at the head of the sorting group, and there is a large difference between the longest and shortest distances from apex to clearance point. Unfortunately, published American descriptions of other yards actually constructed do not directly mention these distances and it is, therefore, not possible to give the average gradient from apex to the most distant clearance point on the lines of Appendix « C ».

Table III gives particulars of hump profiles for two modern American yards — Willard (Baltimore & Ohio R. R.) see note (1) below, and N. Platte (Union Pacific R. R.) note (2) below, and where distances have had to be scaled from diagrams, these have been so indicated. It also includes figures for a « typical » yard for which calculations and graphical methods of design are given in the Proceedings of the A. R. E. A. (Volume 33 : 1932 and Volume 34 : 1933). This is a theoretical layout approaching the ideal design, and uses lapped switches to a greater extent than usual.

(1) *Railway Age*, 23-10-1948; *Railway Signalling and Communications*, Nov. 1948.

(2) *Railway Age*, 30-10-1948; *Railway Signalling and Communications*, Mar. 1949.

It will be noted from Table III that Enola and N. Platte yards do not use lapped switches as recommended in the A. R. E. A. Manual. The more compact layout of Willard yard follows the recommended practice. Willard yard is also of interest in that it is one of the first in the U. S. A. to be equipped with only two retarders in series.

Average gradient between apex of hump and farthest clearance point.

The problem of designing the hump profile has, since the subject was dealt with by Dr. Gottschalk (Report No. 4, *Bulletin*, January, 1930) been approached differently by the British and American Administrations, mainly because the comparatively large retarder capacity necessary for American conditions requires additional investigation to ensure its proper distribution along the profile.

In both countries, the calculation of the total fall from apex of hump to clearance point and retarder capacity required is carried out by the usual methods of applied mathematics. This calculation is necessarily preceded by an assessment of the running characteristics of vehicles and of track resistance, combined with experience of existing yards supplemented in some instances by tests with actual vehicles. A solution to the additional American problem of distributing retarder capacity cannot be conveniently obtained by calculation only, and during the years 1932-1934 the A. R. E. A. published in their Proceedings details of graphical methods for the development of a hump profile of pre-determined drop and retarder capacity.

So far as British conditions are concerned the subject was dealt with at some length by Mr. J. C. Kubale in his paper on « Gravitation Yards » to the (British) Institution of Signal Engineers (Proceedings 1938).

The basic principles of hump design are of course common to all countries, and recommendations have been published in

TABLE III.

Hump profiles in U. S. A. yards.

YARD	Enola westbound	Willard	North Platte	A. R. E. A.
ADMINISTRATION	*Pennsylvania*	*Baltimore and Ohio*	*Union Pacific*	Theoretical design
Sorting tracks :				
Number	35	32	42	45
Track centres (ft. — in.)	12′ 6″	13′ 0″	14′ 0″	13′ 0″
Distance, hump to clearance (ft.)				
Longest	1 680	830 (1)	1 350 (1)	1 100 (2)
Shortest	880	715 (1)	1 000 (1)	920
Average gradient hump to farthest clearance :				
Per cent	1.31	1.56	1.33	1.44 (2)
1 in	76	64	75	70
Distance, hump to king switches (feet)	250	250 (1)	250 (1)	225
Retarders				
Number in series	3	2	3	3
Aggregate length of series (track feet)	269	192	225 (1)	250 (approx.)
Remarks	Standard leads used	Lapped leads used for « jack » switches	Standard leads used	Lapped leads used for «king», «queen» and «jack » switches

(1) These distances have been scaled from published diagrams.

(2) The distance between apex and the farthest clearance point adopted for the specimen calculation published in the A.R.E.A. proceedings was 1 194 feet, which is the distance measured along the track between the apex and a line drawn across the yard, beyond which the tracks are straight and parallel.

the various editions of the A. R. E. A. Manual of Railway Engineering. These do not lay down new principles for the design and construction of marshalling yards, but they have been kept up to date and American methods of design and calculation conform with them both in principle and in detailed arrangement. The following extract is reproduced from pages 14-22, paragraph 325, headed « Hump Yards with Retarders — Design of Gradients » :—

« *Hump yards with retarders — Design of gradients.*

a) Two basic operating conditions should be considered in designing the gradients of a classification yard :—

1. The heavy easy-rolling car moving under the most favorable running conditions (hot weather, following wind. etc.).
2. The light hard-rolling car moving under the least favorable running conditions (cold weather, adverse winds, etc.).

b) Sufficient difference in elevation, or drop, must be provided from the summit of the hump to the clearance point of any classification track to ensure that the hard-rolling car under adverse conditions will roll at least into clear on its classification track; however, it is fundamental that cars shall not accelerate unduly after leaving the last retarder, if damaging impacts are to be avoided. Hence the gradients that should be provided below the last retarder must be such as will result in little, if any, acceleration of the easy-rolling car under favorable conditions. Thus, the drop from the summit of the hump to the end of the last retarder should be « A » minus « B », where :—

A is the drop required between the summit of the hump and clearance point, based on the hard-rolling car under adverse conditions, and

B is the drop required from the end of the last retarder to clearance point, based on the easy-rolling car under favorable conditions.

This drop between the summit of the hump and the last retarder, should be so apportioned that :—

1. The hump gradients will quickly separate the cars or cuts to provide the spacing necessary for the free throwing of switches.
2. The gradients through the last retarder are sufficient to start an average rolling car which has been stopped in the last retarder. »

In order to apply clauses *a*) and *b*), and to arrive at the average gradient of the hump between the apex and most distant clearance point, it is necessary to fix values of resistance for the good running and bad running vehicles which use the hump. In Great Britain, standard values for resistance have not become established and each yard is considered individually taking into account :—

a) Resistance due to curvature, switches and crossings.

b) Average weight of vehicles.

c) Average number of vehicles in cut.

d) Type of bearing i.e. grease or oil axle box lubrication.

e) Time vehicles stand before humping.

f) Variations in temperature.

g) Wind resistance.

The average resistance for a bad running vehicle assessed as above, and expressed as a percentage of the weight of the vehicle, is equivalent to the required average gradient between the apex and the farthest clearance point.

With regard to British retarder yards, from Appendix « C » and Fig. 7, it will be seen that the average gradient varies from 1.87 % for Hull (Inward) yard to 1.35 % for Toton (Up) yard. At the latter yard the traffic mainly consists of

loaded mineral vehicles and allowance has been made for an increasing proportion of the better running oil axle-box vehicles.

For recent American retarder yards the average gradient of the profile, as indicated in Table III, is approximately 1.4 %.

For the purpose of estimating the separation of vehicles, however, it is also necessary to know the normal maximum and minimum resistance for vehicles, i.e., resistance for normal « bad-runners » and « good-runners ». In the « Engineer », January 1932, values of .80 % and .22 % respectively were quoted, but from an examination of the profiles submitted, it would appear that they are now taken as being between the approximate limiting values of 2.00 % and .50 % respectively, these figures including allowance for variables as listed under *a*) to *g*) above.

The principal car resistance figures quoted in the A. R. E. A. Proceedings are:—

a) Average resistance of hard rolling cars under adverse conditions between apex of hump and leaving end of last retarder . . .	1.40 %
b) Average resistance of hard rolling cars under adverse conditions between leaving end of last retarder and clearance points . .	.90 %
c) Average resistance of heavy easy rolling car under favourable conditions beyond last retarder .	.22 %

In using the above figures compensation is made for curvature and for switches and crossings.

It is noted that it is the practice in the U. S. A. to adopt different values for car resistance, the greatest value occurring where the gradient is steepest.

This variation of resistance along the profile is known to occur with British vehicles; Mr. J. C. Kubale noted in the paper referred to above that for a typical bad running vehicle the variation was 2.60 % to 1.85 %.

Profile in vicinity of apex of hump.

Fig. 7 shows that on the approach side of the hump apex a short rising gradient is provided to close up the vehicles and this gradient requires to be of sufficient length to ensure that the longest cuts can be uncoupled. If the vehicles are not uncoupled before this gradient is reached, it should extend far enough back to ensure that the longest cut can be disconnected. At Hull (Inward) yard the gradient required is very short as the reception tracks are rising.

At the apex of the hump, the radius of the vertical curve provided in British retarder yards varies from 528 ft. to 660 ft. It can be shown that if the radius is more than 1,333 ft. vehicles 20 ft. long and having resistance of 2 % and 1 % will not separate when the vehicle of higher resistance is pushed over the hump first. In American retarder yards, the vertical curves are approximately twice as long as in Britain and of four times the radius.

In Great Britain, the initial falling gradient on the hump profile varies from 5.88 % to 5.00 % (1 in 17 to 1 in 20) — the latter gradient has been adopted at Toton (Up) yard where loaded vehicles predominate. In the U. S. A. the initial gradient in recent yards is 4.00 % (1 in 25).

The short initial gradient on the hump is, of course, the maximum occurring in the yard, and for British conditions the gradient of 5.88 % (1 in 17) does not usually cause difficulty with any type of engine or vehicle. The maximum gradient permitted is governed more by the necessity to provide a suitable vertical curve in the limited length available. It is essential that the smallest possible radius of vertical curvature be adopted, otherwise the proper separation of the cuts will not be obtained before the king switch.

In practice the required radius of vertical curvature at the apex cannot be provided to permit of all types of vehicle passing over it, and consequently other arrange-

ments have to be made to avoid certain units passing over the hump. In British retarder yards certain vehicles with a very low underside clearance or having an exceptionally long wheel-base, have to be prohibited from passing over the apex of a hump, and this may also apply to sets of coupled vehicles carrying long rigid loads. At Toton (Up) yard a short level section was introduced into the longitudinal profile at the apex of the hump in order to shorten the length of the vertical curve on the descent side, with the result that it has reduced considerably the number of vehicles which would otherwise have been precluded from passing over the hump.

We have no detailed information concerning the factors which govern the vertical curves adopted in the U. S. A.

Profile between apex of hump and clearance point.

After the steep initial gradient, the British practice is to provide a gradient which will cause the majority of vehicles to accelerate by gravity into the switching area. This gradient is also provided through the retarders in order that the effect of collision, between vehicles which may be stopped in the retarders and following vehicles, can be minimised.

Beyond the retarders the gradient provided in recent British yards is .50 % (1 in 200). In the U. S. A. varying gradients are provided beyond the retarders, as indicated by the profiles reproduced in Figs. 4 and 8, for North Platte and Enola yards. The principal reasons for this are :—

1) Hand brakes on U. S. A. vehicles (with the hand wheel located at roof level) are not so accessible as on British vehicles.

2) The desirable speed at contact of U. S. A. vehicles should not exceed 2 m. p. h. in order to enable coupling to take place without damage. In the U. S. A. therefore the release speed from the last retarder has to be very carefully regulated, and the gradients immediately beyond the retarders, and indeed throughout the sorting sidings, are designed to be non-accelerating for the easy running vehicle. Apart from the question of avoiding damage, this consideration does not apply on British Railways where automatic couplings are not in use on freight vehicles.

In the U. S. A. compensation is provided immediately beyond the retarders for curvature and for switches and crossings and, clear of the crossing work, for curvature only, and usually results in the outer tracks being at a level 1 to 2 ft. below that of the centre tracks. It will, therefore, be appreciated that if such cambering was not provided and the centre tracks were given the drop required for those on the outer tracks, additional retarder capacity would be necessary for the centre tracks. For British layouts, the difference in level between the centre and outer sidings would be of the same order if cambering was adopted, but as British vehicles weigh considerably less than American vehicles, the retarders are able to provide the extra braking power required for the centre tracks, and no cambering has, therefore, been carried out.

Any compensation provided in the switching area immediately beyond the retarders is necessarily a compromise, on account of the various tracks and fans having to attain a common level at the leads. The compensation can, however, be adjusted clear of the crossing work and the graphical method of detailing the slopes considerably facilitates the design. Compensation on these lines was carried out in the U. S. A. prior to 1930, but since that date the publication of the graphical methods of detailing the slopes, and the increased knowledge of the running characteristics of vehicles, has clarified the matter from the designers point of view.

Beyond the switching area, and as far into the sorting sidings as possible, the non-accelerating gradient provided in British

yards is normally .50 % (1 in 200). The distance over which this gradient extends has been varied in the British yards according to the nature of the traffic and vehicles, and in some instances to keep the amount of earthwork within reasonable limits. In the U. S. A. the non-accelerating gradient in recent yards is appproximately .20 % (1 in 500) and in many earlier yards the figure was frequently .30 % (1 in 333).

Ideal braking methods.

The questionnaire suggested that information concerning the hump profile should take into account ideal braking methods.

Railbrakes in the form of retarders are provided at the head of the sorting group for the following purposes :—

1) To adjust the spacing between cuts of vehicles having different running characteristics by means of « interval » braking.
2) To provide for additional variations in the running characteristics of the vehicles caused by weight, track resistance, temperature, wind, etc.
3) To control by « distance » braking the gravitation of vehicles into the sorting sidings, each of which may offer a resistance varying according to the amount of curvature and crossing work on the route, and the compensation provided.

In practice, the braking methods approach the ideal if :—

a) The rate of humping is not reduced, by an excessive amount of braking, below that at which separation is intended to take place at the leads in advance of the retarders.

b) The « distance » braking is sufficiently effective to avoid excessive speeds of contact with vehicles already in a siding.

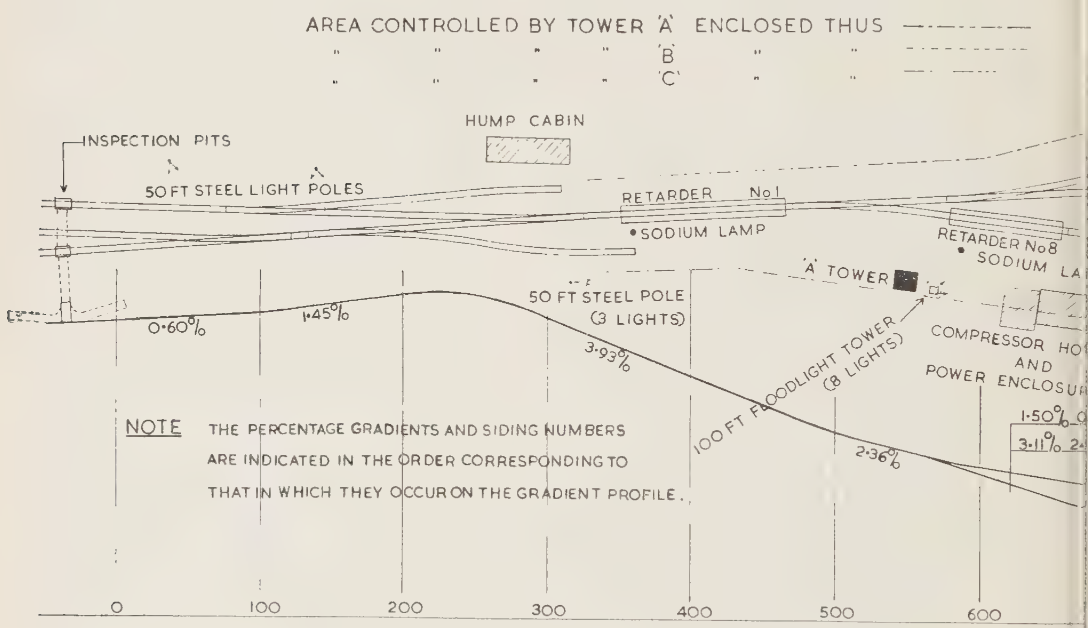
The steep initial gradient and the primary and secondary leads are, in British yards, so arranged that all vehicles can be separated at the switches with a maximum humping speed of about 2 m. p. h. (3 ft. per sec.). The normal humping speed, however, does not exceed 1.7 m. p. h. (2.5 ft. per sec.) so that there is no probability of collisions occurring before primary and secondary separation takes place. Also, in British yards, the retarders are so placed on the profile (usually between the secondary and tertiary leads) that a good running vehicle will not overtake a bad running vehicle before the former is checked by « distance » braking.

In British yards, the humping speed is affected by the probability of good running vehicles, which have been distance braked in a normal manner and are moving slowly through the switching area beyond the retarder, being overtaken by an unretarded bad running vehicle. In these circumstances the latter would have to be retarded, and in the case of exceptionally bad runners, the vehicle would not reach its clearance point in the sorting siding. In practice, the probability of such conditions arising is reduced by the switching which may have taken place in advance of the retarders, or which may take place immediately beyond the retarders before collision can occur. The amount of such switching depends upon the incidence of the cuts into which a train is divided.

In order to improve separation beyond the retarders, the gradients should, if possible, be compensated for curvature and for switches and crossings. The release speeds from the retarders will then be more uniform, thereby reducing the need for « interval » braking. The switching area beyond the retarders should be made compact, as less time is then required for slow moving vehicles to run clear. The brake operator can therefore improve the « distance » braking as he is able to use a wider range of release speeds.

Modern means of communication (loudspeakers, teleprinters, etc.) enable the brake operators to receive information concerning the vehicles in good time, and in the event of difficulties occurring beyond the retarders instructions to ground staff or to

FIG. 8 ENOLA YARD PENNSYLVANIA R.R.



the operator controlling humping can be given without delay.

In the U. S. A. the method of braking is different from that in Great Britain in that three retarders in series are usually employed. The speeds of the vehicles are controlled and spacing is effected by « interval » braking in the first and second sets of retarders, and the function of the last set of retarders is as in British yards, mainly « distance » braking. Allowing for the greater length of vehicles, the humping speed in the U. S. A. (normally about 3 m. p. h.) gives a time interval between single vehicles at the apex of approximately 10 seconds.

D. — Braking installations.

Since the Madrid Congress in 1930, no new basic principle of design has been introduced and developments have been confined to the improvement of existing types.

Three types of retarder are in use :

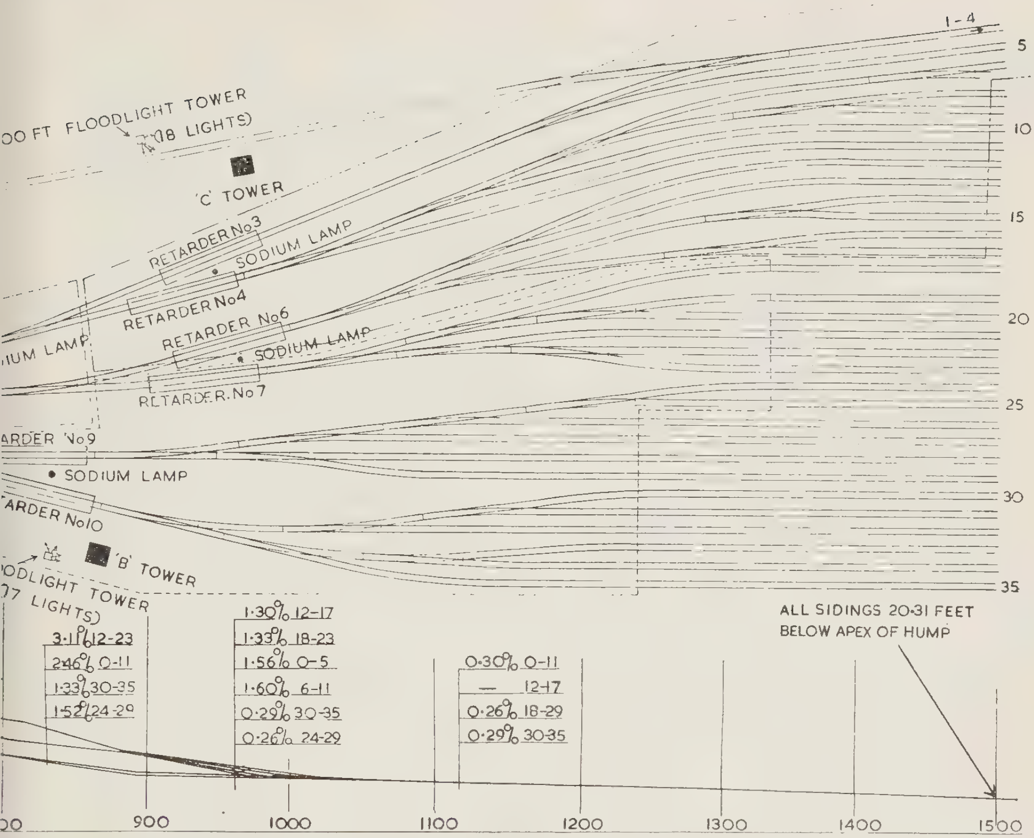
a) Hydraulic.

b) Electro-pneumatic.

c) All-electric.

The « eddy-current » retarders, installed at Whitemoor (Down) yard, were removed in 1949 after 17 years service.

In order that the amount of work carried



out in Great Britain, India and the U. S. A. can be compared, the number of yards equipped with retarders in each country is given below :—

COUNTRY	Up to 1930	1931 to 1948	Total
Great Britain	1	4 (1)	5
United States of America..	30	22	52
India	—	1	1

(1) Includes one under construction.

Position of Retarders.

In all the British marshalling yards, except Whitemoor (Down) yard, the retarders are installed between the secondary and tertiary leads to fans of not more than 10 sidings. As explained in the previous section, the location of the retarder in this position is necessary if they are to perform the « distance » and « interval » braking required for satisfactory running beyond the retarders.

In the marshalling yards of the U. S. A., the usual practice is to instal the retarders in advance of the primary, secondary, and tertiary leads. It would not be practicable, either from the braking aspect or from the

point of view of permanent way layout, to concentrate the considerable length of retarders required in one position. The final retarder in American yards usually covers a fan of not more than seven or eight tracks.

The retarder capacity provided in American yards is, as in Great Britain, sufficient to stop with a margin of safety a good running vehicle moving under the most favourable conditions, but in some yards, for example Enola, remotely controlled skates are installed in the sorting sidings a short distance before reaching the clearance points. They are, however, only used to brake vehicles which have left the retarders at excessive speeds, or which have been incorrectly routed.

Hand-placed skates are used in some British yards when necessary, mainly for the purpose of establishing the head of a train. At Hull (Inward) yard, for example, they are used at the departure end of the sorting group.

Description of braking apparatus used.

Descriptions of all types of retarder at present in use were included in the 1930 Reports and we are therefore only giving information concerning developments which have taken place during the past twenty years.

The hydraulic retarder, designed on the « weight-automatic » principle, is at present installed in all the yards in Great Britain and at Naihati yard in India. The early retarders, installed in 1929 at Whitemoor (Up) yard, were removed in 1945 after 16 years service. Their length, at first 50 ft., was increased to approximately 75 ft. after a short period of trial.

The present installations at Whitemoor (Up and Down) and Hull (Inward) yards are all 75 ft. long: at Toton (Up and Down) yards the retarders are of similar design but 62 ft. long. These lengths are measured over the braking rail in each instance.

The British retarders are all placed on concrete foundations. The most recent installation at Toton (Up) yard provides for an inspection pit under each retarder, the four pits being interconnected by a subway situated at the hump end of the retarders. The subway has a clear height of approximately 7 ft., and is 6 ft. wide with access to and from ground level by means of a ramp having a slope of 1 in 8. It provides accommodation for main power supply cables and hydraulic pipe connections to the retarders. The inspection pits under the retarders have a slope towards the subway and provide headroom beneath the retarder cross beams of 6 ft. adjacent to the subway decreasing to 4′ 6″ at the end remote from the subway. The subway includes a drainage channel having a fall to a sump for collecting surface water, the latter being discharged automatically by means of an electrically driven pump. Solid abutments are provided at the other end to take the thrust due to braking.

The retarders at Whitemoor (Up and Down) yards have pits allowing of access under the brakes for inspection and these are connected by pipe and cable ducts. At both these yards concrete slabs have been constructed under the tracks at both ends of the retarders to reduce the impact of vehicles running on and off.

At Hull (Inward) and Toton (Down) yards, the retarders use water as the hydraulic medium, but at Whitemoor (Up), oil is used for this purpose. Oil is also used for the recent installations at Toton (Up) and Whitemoor (Down) yards. Improved functioning of the mechanical portions is thereby obtained and heating of the hydraulic system to prevent freezing in cold weather is obviated.

At Toton (Up) and Whitemoor (Down) yards, compressed air accumulators are incorporated in the pumping equipment instead of the weight loaded type, thus avoiding the construction of an accumulator structure and saving a considerable amount of space.

Other improvements incorporated in the

design of the hydraulic type of retarder include :—

a) The wearing sections on inner and outer braking rails are more easily removed.

b) Screw adjustment provided on outer rail to take up wear.

c) High-pressure gun lubrication.

A cross-section of the recent design of hydraulic retarder is reproduced in Fig. 9, shewing the brake in the raised and lowered positions. The braking rail rises from 1″ to 4 1/2″ above the top of the running rail for wheels 5″ wide. The unit is completely assembled in workshops so that installation can be carried out quickly on site using cranes.

In the U. S. A., both the electro-pneumatic and all-electric types of retarder have continued in use during the last twenty years; no information has been reported concerning the latter type.

The electro-pneumatic retarder has been greatly altered since it was described in the 1930 Reports. In 1931, a retarder, having brake beams which grip the wheels after the manner of the jaws of a nutcracker, superseded the earlier design. It is built up in units of 6′ 3″ in length, so that a series of units can be laid to any multiple of this length. Each intermediate unit is interchangeable and consists of an assembly of levers, actuated by a cylinder, which operates a stiff brake beam 6′ 3″ long.

The main features of the « nutcracker » retarder are set out below and indicated in Fig. 10.

a) The over-all depth and design of the retarder are such that it can be fixed to sleepered track, and the only foundation normally required is a good depth of stone ballast.

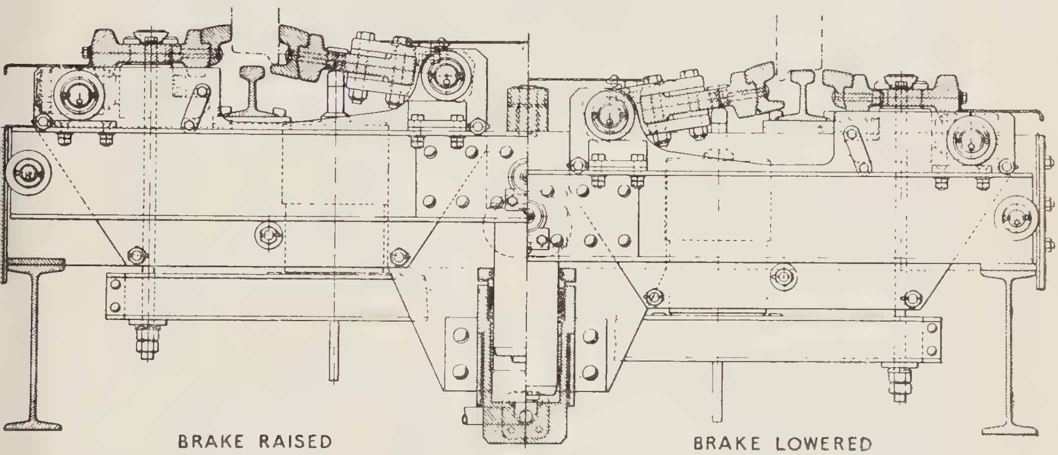
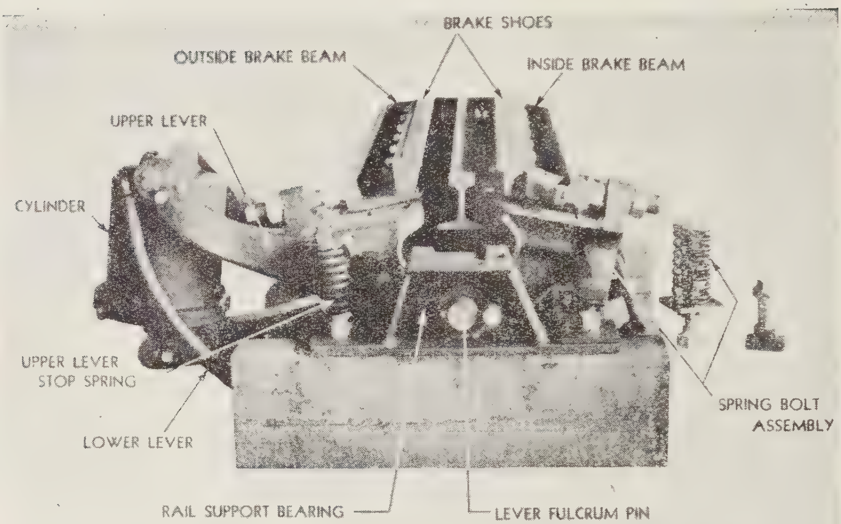


Fig. 9. — Hydraulic type retarder.

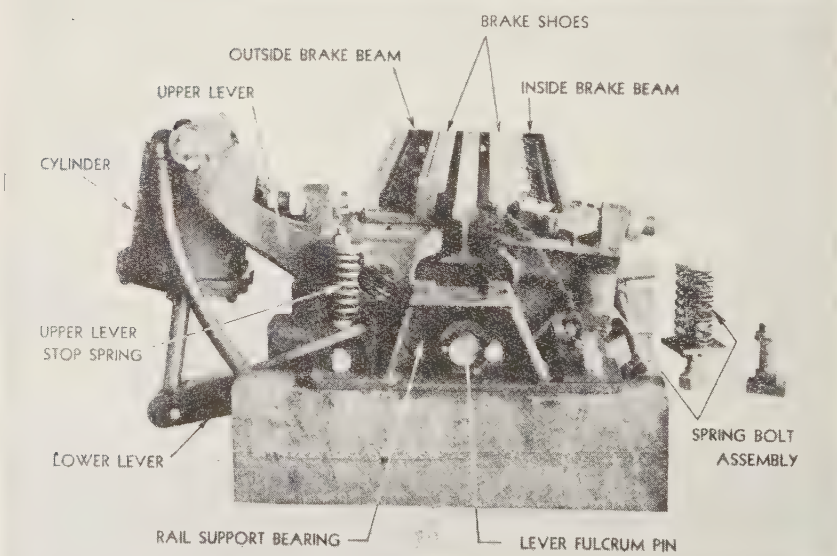
b) The levers and cylinder of each unit turn freely on a pivot, so that the brake shoes adjust themselves to the wheels of the vehicles and give an equal pressure on each side of the wheel.

c) Brake shoes are bolted to the brake beams, both components being 6′ 3″ long. The articulated joint between adjacent beams is spanned by the brake shoe to impart a rigidity to the retarder as a whole, but at the same time giving a certain amount of flexibility to provide for the various widths of wheel and for fixing on curved track.

d) The braking beams rise as they ap-



Cross Section of Retarder in Open Position



Cross Section of Retarder in Retarding Position

Fig. 10. — Electro pneumatic type retarder.

proach the running rail. One type provides for 2 ¼" vertical clearance between the brake beam and the top of the running rail when the brake is open, and the brake beam rises 9/16th in. when gripping a wheel approximately 4 ¾" wide.

e) The cylinder of each unit is above sleeper level and all moving parts are accessible for grease pump lubrication and repair. Brake shoes are easily adjusted or renewed.

f) The retarder can be fixed to one rail only when space is very limited.

g) There is no metallic connection between units fixed to opposite rails, and it is therefore possible to carry track circuits through the retarder if necessary.

h) The braking force is entirely controlled by the operator. Four stages of air pressure are applied to the cylinders, and as each retarder is usually divided into two sections, eight degrees of braking are obtained.

At Enola yard, where the electro-pneumatic type of retarder is installed, concrete foundation slabs are provided 13 ft. wide by 25 ft. long by 17 inches deep at the centre. Under the rail, the slab is reduced in depth to 12 inches and a notched plinth 17 inches wide is provided to support the timber sleepers of the track, which are notched to prevent lateral movement.

A second similar type of foundation has also been constructed at Enola and Willard yards having the running rail bolted direct to the concrete plinth. Cushioning pads are provided under the seating chairs. For both types of foundation an approach slab is provided at each end to reduce the effects of impact.

It will be noted that, as in 1930, there are wide differences in British and American practice, not only in the length and distribution of the retarders, but also in their design. The principal reasons for these differences, so far as we can ascertain in the absence of further information from the U. S. A., are :—

a) In the U. S. A., vehicles weigh up to 90 tons gross or more whereas British vehicles do not generally exceed 32 tons in weight when loaded. The corresponding axle loads are 22 ½ tons and 16 tons. Bogie vehicles cannot be so effectively braked as 2-axle vehicles.

b) The design of retarders in the U. S. A. provides for a more restricted clearance between the brake beam and the top of the rail, thus limiting the height at which a wheel can be gripped.

c) The fall of the hump between the apex and last retarder in American marshalling yards is comparatively greater than in British yards, and more braking capacity is therefore necessary to deal with good running vehicles.

d) Lower release speeds from the last retarder are necessary.

The « eddy-current » retarders installed at Whitemoor (Down) yard remained in service 17 years and during this period each retarder, because of its position between the « king » and « queen » switches, dealt with roughly 50 % of the vehicles passing over the hump. These retarders were eventually replaced by the hydraulic type.

With regard to the skates used in American marshalling yards, the type used at Enola consists of a simple design of shoe which is placed on the running rail by means of a system of levers. The levers are connected to a piston which is moved, under the control of the brakesman in the control tower, by means of a small compressed air cylinder. The shoe is taken away by the wheel of the vehicle without shock or damage to the mechanism, and is returned to the machine by hand. An all-electric type of remotely controlled skate is also used in the U. S. A. No provision is made for ejection of shoes at a predetermined point.

Staff employed for braking.

In the more recent British installations at Hull (Inward) and Toton (Up and

Down) yards, the brake operator is in a control tower situated to one side of the switching area and just beyond the leaving end of the retarders. The floor level is approximately 20 ft. above rail level. The four retarders are controlled by one man from a panel independent of the point panel.

At Whitemoor (Up) yard, the control tower is built on the centre line of the yard immediately beyond the leaving end of the retarders. From this position it is necessary to have one man, controlling two retarders, on each side of the room. At Whitemoor (Down) yard the control tower is in a similar position, and one brake operator, controlling two hydraulic retarders, is placed centrally at the end of the room facing the hump and a mirror is used to enable the progress of vehicles to be followed through the switching area.

In American yards, it is the practice to arrange the retarder and switch controls on one panel and the operator is responsible for both operations. More than one control tower is usually provided normally situated to the side of the area controlled therefrom and in some recent yards the floor height has been 12 to 14 ft. above rail level.

At Enola yard (Fig. 8) tower « A » nearest the hump controls all the switches (6) before the final retarders, together with the primary retarder and the three secondary retarders. Tower « B » controls 15 switches and 3 retarders, and tower « C » 16 switches and 3 retarders, together with some switches outwith the sorting group. The retarders are in two sections so that there are two sets of controls for each retarder.

Efficiency of braking.

The Administrations report that the above arrangements for controlling the brakes, when associated with the most suitable profile, give efficient braking.

With regard to the retarders themselves, their efficiency from the point of view of interval and distance braking was dealt with in a previous section of this report under « Ideal braking methods ». From the point of view of availability and maintenance cost, the efficiency of the recent types has been greatly improved by the developments described above.

In British yards, the method of maintenance varies according to the facilities which can be offered by the Operating Department. Normally, periodical examination and maintenance of one retarder unit is carried out under complete possession of one fan for a few hours weekly or monthly. Day-to-day examination is programmed to be carried out systematically at times when humping can be suspended, and during the meal periods of the shunting staff. The maintenance operation requiring the longest period of possession is the changing of a worn brake rail. This operation is carried out in one day after the retarder has been approximately two years in service depending upon the intensity of the user.

For the hydraulic retarder a power consumption of approximately .03 units per vehicle humped is typical for British yards.

With regard to supplementary braking, this is not normally required in British and American retarder yards, but in Great Britain one man is usually employed in each fan to deal with vehicles which are running too fast, with non-retarder vehicles, and with exceptional traffics. In Enola yard five or six men are employed to apply hand brakes on the leading vehicles of trains in the sorting sidings.

Retarders in British yards are designed to brake vehicles with wheel widths varying by three-eighths inch maximum within the fixed maximum and minimum widths (from 4.13/16″ to 5.3/16″). They are not, however, suitable for retarding vehicles having bolted or rivetted tyres. No reply on this point has been received from the U. S. A. but it is understood that the retarder designs provide for a considerable variation in wheel width.

Control of retarders.

British Railways have had no experience of operating retarders in two or more sections, but in the U. S. A. both the electro-pneumatic and all-electric types are operated in two or more sections, each usually 40 ft. long approximately.

The main object of dividing the retarder is to give a greater range of braking force, but it also has the advantage that if a vehicle is stopped at the outgoing end of the retarder a following vehicle can be checked at the entrance to the retarder and a collision avoided or its effect minimised.

We have no information concerning apparatus to automatically determine the degree of braking required for vehicles running under different conditions, for example, of vehicle resistance, speed, weather, weight of load, track resistance, etc.

In Great Britain the degree of braking to be applied is a matter of judgment by the operator. The hand controlled valves of the weight-automatic hydraulic retarder are fitted with a pressure balancing device which allows a variable pressure of between 400 and 1,600 lb. per square inch to be applied.

At some British retarder yards alternative high tension electricity supplies are given to each sub-station from independent sub-stations of the Supply Authority. No spare electric power generating units are provided. Duplicate transformers, low tension switchboard and feeders usually are provided to the respective relay rooms, hydraulic pumps, air compressors, lighting, etc. In general, the electricity supply, hydraulic system and the compressed air system, are duplicated to guard against failure and to facilitate maintenance.

E. — Control of point operation.

At the time of the 1930 Congress, power-operated signals and points, with track circuits and control apparatus, were already used in the marshalling yards of Great Britain and the U. S. A. The technical developments which have taken place since 1930 have been derived from those which have occurred in running line practice, especially as regards equipment and buildings. We do not, therefore, propose to describe either equipment or buildings in detail, but to indicate how modern methods have been applied to facilitate the working in marshalling yards.

Point movement.

In the British yards listed in Appendix « C » (except Whitemoor) the travel of the points is effected by compressed air of pressure 30. lb. per sq. in. to 50. lb. per sq. in. The points are not bolted but electric indication is provided. At Whitemoor (Up and Down) yards, the points are operated by all-electric machines (110 volt D. C.). The time of travel of points varies in the different yards from .20 sec. at Hull to .60 sec. (maximum) at the Whitemoor yards. For Toton (Down) yard, the time of travel is reported as .30 to .50 sec.

On the Indian Railways electrically operated points are used at Naihati, Chitpur and Tondiarpet yards. In the U. S. A. both all-electric and electro-pneumatic types of point machine are in general use.

In British retarder yards, « normally de-energised » track circuits are employed. The movement of the points is controlled by a vehicle clearing a track circuit extending for a short distance in advance of and beyond the points. The total length of track circuit should be greater than the longest wheel base of vehicles so that the points are held under such vehicles, and in advance of the points the length of the track circuit should be sufficient to ensure that enough time is allowed for the operation of the relays and points. The control circuit is so arranged that, if movement has already been initiated when a vehicle enters the track circuit, the points can complete their travel. In Great Britain, the total length of the track circuit at the points is 37 to 51 ft. approximately, and it should not be longer than necessary as it is

one of the principal factors governing the humping speed. The length of track circuit provided in advance of the first three sets of points at the following yards is :—

Points	Whitemoor (Up)	Hull (Inward)	Toton (Down)	Toton (Up)
« King »	16′ 6″	20′ 0″	18′ 5″	17′ 6″
« Queen »	16′ 6″	26′ 5″	21′ 0″	17′ 6″
« Jack »	17′ 0″	16′ 5″	15′ 0″	18′ 4″

After the retarders, the selection of suitable lengths of track circuit in advance of and beyond the points is particularly important as the speed of vehicles in this area varies greatly according to the amount of retardation applied. For example, under British conditions, a bad running vehicle may require no braking and run through the « jack » points at a speed of 15 m. p. h., whereas a good running vehicle may be retarded to 4 m. p. h.

In American marshalling yards, point movements are effected by equipment similar to that in British yards. Special circuits have been designed for the operation of « lapped » switches. The minimum length of track circuit in one recently completed yard was 55 ft., of which 22 ft., was in advance of the points and 33 ft. beyond the points. At the « king » and « queen » points however, the lengths of track circuit in advance of the points were respectively 27 ft., and 28 ft.

Stand-by equipment.

The extent to which stand-by equipment is provided depends mainly on the reliability of the primary source of power, upon financial justification for the cost of the additional plant, and upon the facilities required for the maintenance of all plant and equipment associated with the scheme.

In British yards, duplicate electric power supplies (where obtainable) with duplicate power mains between the sub-station and hump building or control tower are provided. Accumulators (lead-acid or nickel-cadmium) trickle charged from the main supply through rectifiers are used to ensure that low voltage D. C. supplies for control circuits and track circuits are not interrupted, and in the case of Whitemoor (Up and Down) yards, a similar 110 volt D. C. supply is required for the emergency operation of the electric point machines. Failure of compressed air supply is provided for by duplicate compressors and receivers, which, however, may be dependent upon the main electric power supply.

At Whitemoor (Up and Down) yards, the primary supply is obtained from a local Railway generating station which has the usual arrangements for safeguarding the supply.

For Enola yard, the power for loud speakers, wireless, air compressors and lighting, is supplied from commercial sources with alternative systems of supply. Power for the control of switches, retarders, and signals is supplied from accumulators trickle charged from the main supply. Compressed air is supplied by duplicate electrically driven compressors, with steam sets available for stand-by purposes, or the brake pipe of locomotives may be connected in case of power failure. The reply submitted indicates that duplicate electrically driven compressors are provided for maintenance purposes rather than as a safeguard against power supply failure.

At Willard yard, where all-electric retarders are installed, a 160 amp-hr. storage battery is fed by a 15 kW 265 volt. D. C. generator driven by a 40 HP motor on the commercial supply (440 volt A. C.). The battery is capable of maintaining emergency supplies for the retarder motors (220 volt D. C.) and for the point motors and track circuits. The latter supply is generated at 110 volt A. C. by means of a 5 HP 265 volt D. C. motor working on the battery. The emergency battery also supplies, during normal working, a proportion of the current required while the retarder motors are in operation. Should the main electricity supply fail for a period exceeding 8 hours, a 15 kW 265 volt D. C. generator driven by a 48 HP gasoline engine supplies the power for the yard.

Control of point movements.

Table V gives a brief description of the methods of controlling the point movements at the head of the sorting group for each of the yards listed in Appendix « C », together with the number of cuts stored, before humping is commenced, or while humping is in progress.

It will be noted that the tendency in British yards is for fully automatic operation of the points, and at Toton (Up) yard, this is effected from a specially designed building at the hump, provision being made for the storage of eight cuts.

For fully automatic and semi-automatic systems, means are provided for immediate changeover to « non-automatic », i.e. individual point operation when necessary.

In American yards, of which Enola is typical, point movements are made by manipulation of switches in the control towers, and track circuits are used to prevent ill-timed movements of the points. At Montreal (Canadian Pacific Railway), and Markham (Illinois Central Railroad U. S. A.) yards, however, point control systems similar to those at the Toton yards are being installed.

In the event of one cut overtaking or being likely to overtake another, it is the duty of the point operators in the control towers of British yards to ensure as far as possible that the correct sequence of cuts is maintained. For this purpose they communicate as necessary with the brake operators and with the hump operator in the hump building. At Toton (Up and Down) yards « stepping » buttons are provided applicable to the « jack » points, on the control tower panel. In the event of one cut overtaking another on a « jack » point track circuit the correct sequence of the following cuts can be maintained by depression of the appropriate « stepping » button. If the controlling point track circuit has already been occupied before the cut running out of sequence can be switched by the operator to its correct destination, then it must follow the preceding cut into the sorting group.

Descriptions of installations for controlling point operation.

The following descriptions of the indoor equipment provided for controlling point operation are given for Hull (Inward) and Toton (Down) yards. The former is a fully automatic installation controlled from the tower, whereas at Toton (Down) the system is semi-automatic in that the first three separations are pre-set from the hump building, the remaining separations being effected by manipulation of thumb switches in the control tower.

a) *Hull (Inward) yard.*

At Hull (Inward) yard, the layout of the switching area is indicated diagrammatically on the point control panel, with thirty control buttons at the bottom of the panel, each of which sets up a complete route to one of the thirty sorting sidings. At each point of separation on the diagram, there is a thumb switch for the individual control of the points, with a yellow indication on each side, one of which lights up according to the position of the points. These switches must be in their centre position for fully automatic working.

TABLE V.

Methods of controlling point movements.

ADMINISTRATION	Marshalling yard	Number of cuts stored	Brief description of system and preference
British Railways (Eastern Region)	Whitemoor (Up)	50	Storage effected for « king », « queen » and « jack » points in magazine type of storage drum by point operator in control tower, working from « cut » list transmitted from hump by pneumatic tube. Remaining points to sorting sidings controlled individually by switches on a diagrammatic panel. This semi-automatic system is reported to give faster working than the fully automatic system and to provide greater flexibility for controlling point movements beyond the « jack » points.
British Railways (Eastern Region)	Whitemoor (Down)	50	— d° —
British Railways (N.E. Region)	Hull (Inward)	Nil	Fully automatic operation for all points by progression relay system. Route set by push button when preceding cut has occupied « king » point track circuit. Point operator works from cut list transmitted from hump by pneumatic tube. Individual operation of points can be adopted when necessary. Fully automatic system is reported to be preferred as there is less responsibility for operator, who is thus at liberty to follow the movement of cuts through the switching area.
British Railways (L.M. Region)	Toton (Down)	8	Storage effected for « king », « queen » and « jack » points by push buttons in hump building. Remaining points in sorting sidings controlled individually by point operator in tower. Siding number of cuts is chalked on vehicles and transmitted to tower by teleprinter controlled by push buttons in hump building. Individual point operation of « king », « queen » and « jack » points from tower can be adopted when necessary. It is reported this method of operation has proved satisfactory for the layout and conditions associated with the yard.

TABLE V.

Methods of controlling point movements. *(Continued)*

ADMINISTRATION	Marshalling yard	Number of cuts stored	Brief description of system and preference
British Railways (L.M. Region)	Toton (Up)	8	Similar to that at Toton (Down) yard, except that fully automatic operation is effected by depression of the appropriate siding button on a panel in the hump building, and provided the three-position thumb switches on diagrammatic panel of the point area in the control tower are in the « automatic » position for the particular route. In the event of cuts overtaking, the point operator in the tower can switch any set of points from automatic to non-automatic operation by turning thumb switch as necessary. It is reported that an expression of opinion on this method cannot be given until the yard has been longer in operation.
British Railways (Eastern Region)	Mottram	Nil	Similar to Hull (Inward) yard, Fully automatic operation of all points : Individual operation of points can be adopted, and it is reported that this method is preferred as working can be faster.
British Railways (Western Region)	Severn Tunnel Junc. (Up and Down)	Nil	Similar to Hull (Inward) yard. No preference reported.
British Railways (Western Region)	Banbury	Nil	Similar to Hull (Inward) yard. No preference reported.
East Indian Railways	Naihati	50	Storage effected for « king » points only. Preference for fully automatic system in large yards is reported.
Pennsylvania	Enola	Nil	Individual operation of points from three control towers. No preference is reported.

For fully automatic working the route for the first cut is set by pressing the appropriate button before humping commences, but the button for pre-setting the route for the second cut cannot be depressed until the first cut has occupied the « king » point track circuit. Mechanical locking is provided to prevent more than one button being pressed at one time, and the button for each successive cut when depressed is not released until the « king » point track circuit is occupied by the cut preceding it. A green light on the panel then indicates « next route clear » and a buzzer sounds simultaneously to attract the attention of the operator. When any button is depressed, the green light is extinguished and the storage for the « king » and « queen » points becomes effective. The clearance of the track circuit in advance of a retarder controls the operation of the progression relay system for the remainder of the route. A special circuit arrangement, permitting two cuts being in a retarder at the same time, provides for this non-track-circuited portion of the route.

The progress of a cut on its way to the sidings is indicated on the panel diagram by red lights which are illuminated as successive track circuits are occupied.

The top of the desk on which the panel is mounted is hinged at the front, so that contacts and wiring can be examined from the back without unduly interfering with operation of the push buttons and thumb switches.

« Cancel » and « Stop » buttons are also provided on the panel, the latter controlling the « stop » aspect of the hump signal irrespective of control exercised at the hump building. When it is necessary to clear the storage the « cancel » button is pressed and the thumb switches used to control the points as required. There is space on the panel for the « cut » list, which is transmitted to the tower from the hump by pneumatic tube.

b) *Toton (Down) yard.*

The panel in the hump building is provided with buttons applying to each siding, together with « cut » buttons numbered 1 to 6 for transmitting the number of vehicles in each cut to the operators in the control tower. The operator in the hump building observes the siding numbers chalked on the leading ends of vehicles as they approach the apex and presses the appropriate « siding » and « cut » buttons. (See Figs. 11 [*a*] and 11 [*b*].)

The following operations are thereby effected :—

(i) Pre-setting of a route up to and including the « jack » points.

(ii) Printing the number of the siding, and the number of vehicles in the cut, on paper tapes in front of the point and brake operators in the control tower.

Additional buttons and thumb switches are accommodated on the panel for :—

a) announcing « non-retarder » vehicles;

b) announcing « cut not described »;

c) clearing storage;

d) operating humping signals,

and a microphone is mounted on the back of the panel.

An extension of the panel in the hump building has a diagrammatic layout of the lines in the vicinity of the hump, with thumb switches for operation of points and running signals, and lights for indicating track circuit occupation and position of points.

The panel for point operation in the control tower, see Fig. 12, is based on a diagram of the layout from the hump to the last sets of points leading into the sorting sidings and accommodates the following switches and indications :—

(i) Two-position thumb switch for point operation with red light at pivot, which

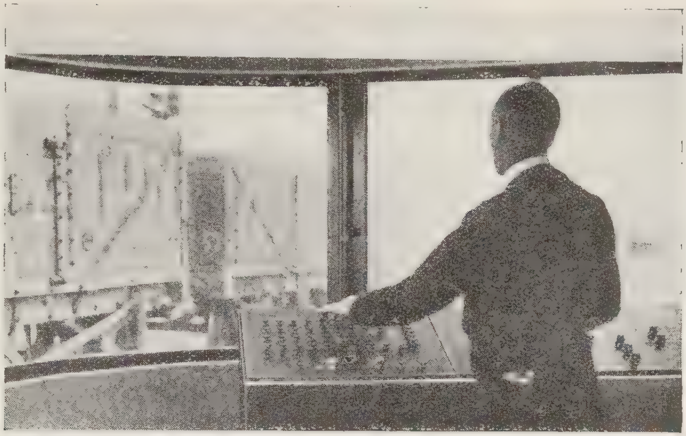


Fig. 11 (a). — TOTON (Down) yard — *British Railways* (L. M. Region). View from hump building.

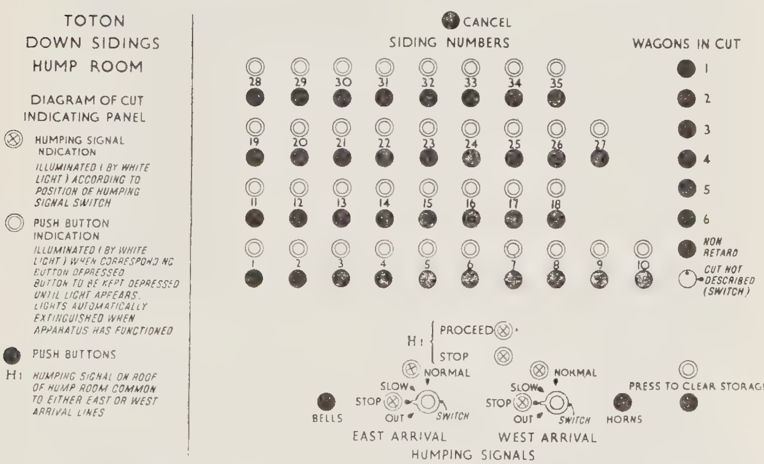


Fig. 11 (b). — TOTON (Down) yard. — *British Railways* (L. M. Region). Diagram of route setting and cut indicating panel in hump building.

is illuminated when the point track circuit is occupied. The « king », « queen » and « jack » point thumb switches have an additional « automatic » position.

(ii) White light on each side of thumb switch for indicating the position of the points.

(iii) Red lights illuminated when intermediate track circuits between « king » points and retarders occupied.

(iv) Buttons applying to « king » and « jack » points, for cancellation of one cut in the automatic storage in order to maintain correct sequence of following cuts.

(v) A thumb switch for placing the humping signals to « stop » in emergency.

An installation on similar principles to the above has been introduced at the more recently constructed Toton (Up) yard, except that the route is pre-set throughout from the hump building, i.e. fully automatic operation.

It will be noted that when full or semi-automatic operation is in force the depression of the appropriate buttons on the panel in the hump building combines both point operation and actuation of the cut indicating apparatus.

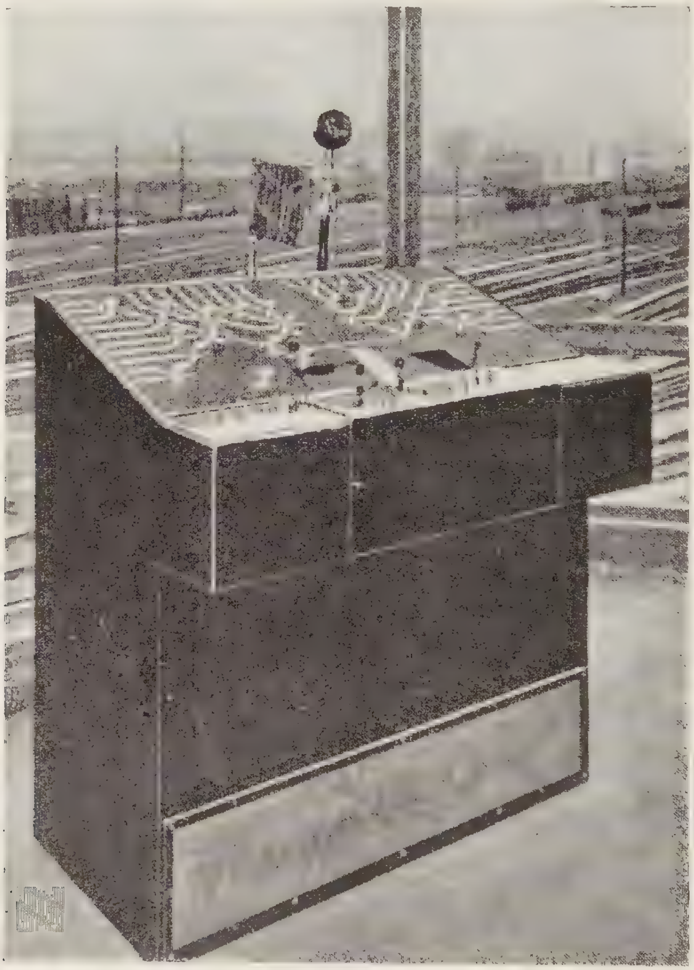


Fig. 12. — TOTON (Down) yard. — *British Railways* (L. M. Region).
Point operator's panel in control tower.

Position of point and brake operators.

In British retarder yards the brake oper-

ator in the control tower is positioned as near as practicable to the leaving end of the retarders.

At Whitemoor (Up and Down) yards the point operator in each tower sits at the window facing the sorting sidings, while at the other yards, which have the tower to one side of the switching area, the point operator's position is at the same long window as the brake operator, but at the end of the room nearest to the sorting sidings.

At all the British retarder yards, the floor of the control room in the tower is approximately 20 ft. above rail level. Where specially designed hump buildings are provided, that is, at Toton (Up and Down) yards, the floor is slightly above rail level. An illustration of the Toton (Down) hump building is given in Fig. 13. At Banbury and Severn Tunnel Junction (Up and Down) yards, the control buildings are situated near the hump and the heights of the floors above rail level are 9 ft. and 8 ft. respectively. At Mottram the point operator's cabin is located near the « king » points and the floor is 12 ft. above rail level. It will, therefore, be noted that the operators have a clear view of the yard in all directions.

In the control room of the towers in British retarder yards, long windows extend almost down to floor level, but the height is not more than necessary in order to avoid sun glare. A canopy is provided over the windows, and at Whitemoor (Up and Down) and Mottram yards the glazing is sloped with the object of avoiding reflection. At Toton (Up and Down) yards the hump buildings are provided with a bay window, in which the panel is positioned so that the operator has at all times an uninterrupted view through an arc of at least 180 degrees.

Fig. 13. — TOTON (Down) yard. — *British Railways* (L. M. Region).
Hump building (on left). Control tower (in distance).

At Enola yard, the usual American practice is followed in that towers are provided to the side of the switching area, see Fig. 8, and the panel embodies both retarder and point controls. The former are arranged

above the controls of the points immediately following the retarders and the panel is operated by one man. The floors are about 22 ft. above rail level and each operator is able to observe the movement of vehicles from the apex into the sorting group. The glazing is not sloped, but this feature has been incorporated in some American control towers where heat absorbing and tinted glass are frequently used. In some recent buildings double glazing has been provided and ceilings have been covered with special acoustic linings.

Signalling in marshalling yards.

An important feature in modern yard operation is the provision of efficient control over the speed of movement of engines engaged in propelling vehicles over a hump. This control is normally exercised by a man located at the hump, who must be in a position to transmit to the driver of the humping engine the necessary instructions for starting, stopping and regulating humping speed, etc. If the engine driver is to respond promptly to these instructions, he must receive them in an unmistakable manner.

The method of controlling the movement and speed of trains approaching the hump varies considerably and the following are descriptions of typical installations :—

a) *Whitemoor (Up) yard.*

Two three-position semaphore signals are sited 50 ft. in advance of the hump apex, each applying to one of the two fans of reception lines and providing for a « stop » indication and two humping speeds. Previously at this yard, two four-aspect colour light signals operating simultaneously were provided and applied to both fans of reception lines. These signals were removed on account of poor visibility in sunlight (with the sun behind the signals) and in addition with two engines in use it was necessary to give verbal instructions to drivers at the far end of the reception lines as to which train should be shunted first. Repeater signals have not been provided.

b) *Hull (Inward) yard.*

A three-aspect colour light signal is provided near the apex and repeated once on the approach side. This indication applies to all the six reception lines.

c) *Toton (Down) yard.*

Lunar-white three-aspect position-light signals are used to control humping operations. They are repeated five times along the main arrival line which is on a curve, and also along the adjoining line used as a hump engine run-round line and for the humping of trains drawn up via the hump avoiding line from reception lines parallel with the sorting sidings. Another of these signals is located on the hump building, operating with whichever series of repeaters is in use, and which is controlled by switches on the panel in the hump building.

d) *Toton (Up) yard.*

Lunar-white three-aspect position-light signals are used to control humping but features additional to those at the Down yard have been provided, see Fig. 14.

In designing the reception group, the lines were planned to be laid out to a straight alignment and additional space was allowed between alternate lines to permit of a series of humping signals being erected.

In order to indicate to which of the lines on either side of the humping signals the aspect applies, one of two lunar-white indication lamps fixed one on either side of the signal face, becomes illuminated in unison with the humping aspect, thus indicating whether it applies to the reception line on the left or that on the right.

There are three rows of these signals across the reception lines, and the first two rows are double sided. This enables the driver of a humping engine to look either way if visibility is not good.

These position-light signals only apply to humping and draw-back movements out of the sorting sidings on to the run-round line for re-shunting, the latter being provided for by illuminating the « Stop »

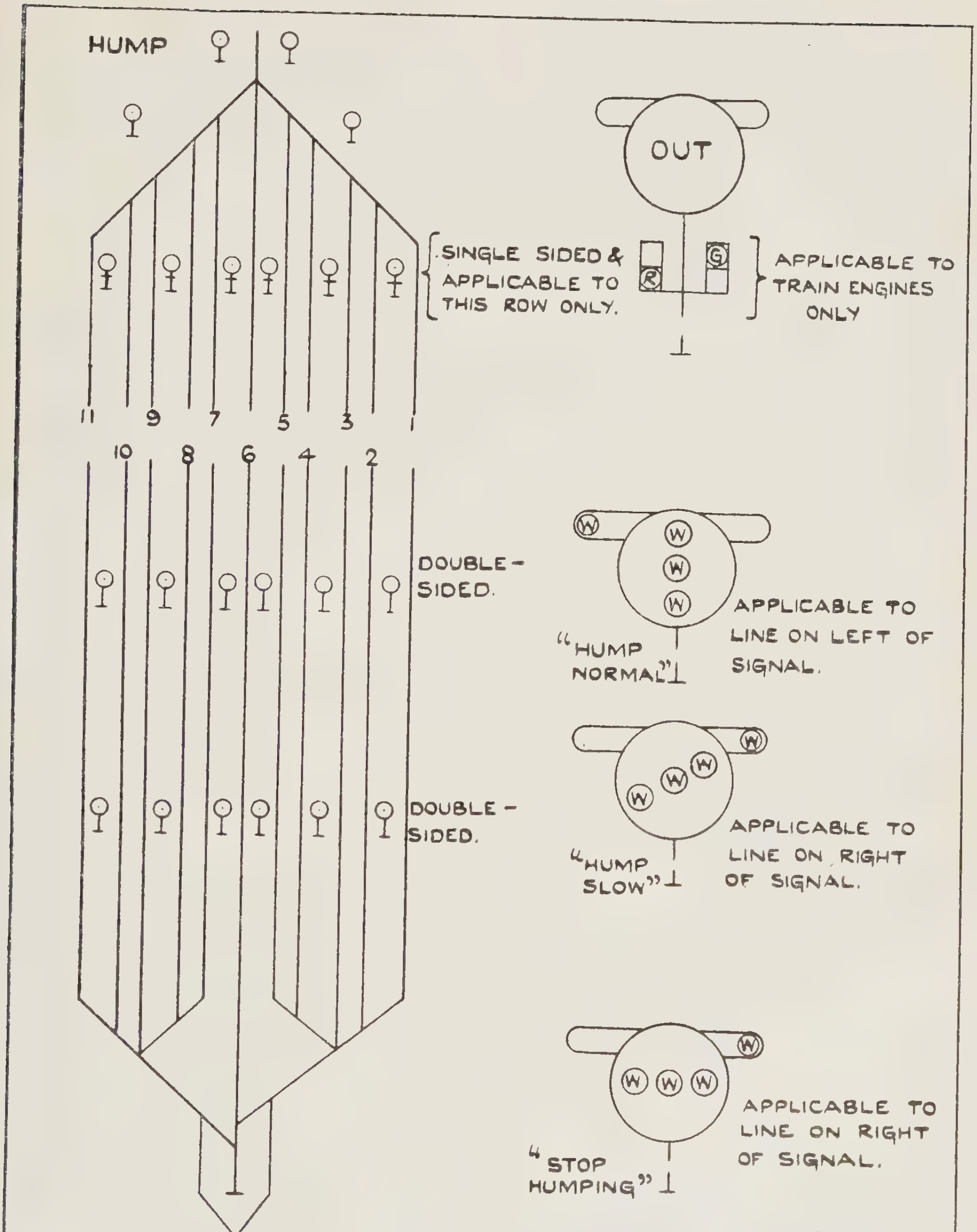


FIG. 14. TOTON UP YARD. B.R. (L.M.R.)
DIAGRAM ILLUSTRATING RECEPTION LINES & ARRGT OF SIGNALS WITH EXAMPLES OF ASPECTS DISPLAYED.

aspect on the signal applicable to that line as soon as the last vehicle drawn back is clear of the hump.

Single sided repeater signals in series with whichever row along the reception lines is for the time being displayed, are provided outside the converging points of the reception lines and on the hump building.

On the last row of humping signals across the reception lines, bracket arms carry signals which normally display a red aspect indicating to drivers of incoming trains where they must come to a stand. A green aspect replaces the red when the train engine is to move forward after uncoupling from its train. Drivers of incoming trains work to these colour-light signals and not to the position-light humping signals.

The entire system is so arranged that :—

(i) not more than one series of position-light humping signals can be displayed at one time;

(ii) not more than one applicability indication can be displayed at one time, i.e. for not more than one reception line;

(iii) when the red (stop) aspect for a train engine is displayed neither the green (release) nor lunar-white (humping) aspects for that particular line can be illuminated, and, vice versa.

Thus the eleven lines (10 arrival and 1 run-round, any one of which will accommodate an engine, 75 vehicles and brake-van), together with the converging area and the hump, are adequately covered for all train arrival and hump shunting purposes by signals carried on a comparatively small number of posts.

These facilities are controlled from a panel in the hump building mentioned. The position-light humping signals, also the train engine stop and release signals, are operated by one rotary master switch in conjunction with a set of push-buttons — one for each reception line.

e) *Toton (Up and Down) yards.*

The lunar-white position-light signals display the following aspects :—

Vertical	Hump at normal speed.............	o o o
Inclined	Hump slow........	°o o or o o°
Horizontal	Stop	ooo

When out of use the signals are not illuminated. Normal and slow humping speeds commensurate with the general character of the traffic and the running of vehicles off the hump are prescribed for the guidance of the drivers. Diesel electric locomotives fitted with suitable speedometers are employed for this work.

f) *American yards.*

The A. R. E. A. (Signal Section) recommend the following aspects and indications :—

ASPECT	INDICATION
Red...........	Stop
Green	Proceed at normal hump speed
Double yellow..	Proceed at medium hump speed
Yellow	Proceed at slow hump speed
Flashing Red ..	Back up

Other combinations of colours are, however, frequently used. Various types of hump signal are installed, but the colour-light type is the most usual. Closing down movements in the sorting group are controlled by « trimmer » signals on the hump and at the leads entering the fans. Typical aspects and indications are :—

Red — Engines in sorting group to remain beyond clearance points. Humping is proceeding.

Green — Engines in sorting group may enter lead. Humping is stopped.

At each set of points is a colour-light target with lamps facing in both directions, with different coloured indications (for example, green and yellow) for the two positions of the points.

Safety arrangements.

In both British and American yards, the hump signals are controlled from the hump, but provision is made for the point operator, in the event of emergency, to change the humping aspect to « stop ».

Certain signalling as necessary apart from humping indication is provided in British marshalling yards. Train engine release movements are usually controlled by signals operated from the hump and interlocked with humping signals. In British yards, run-round movements of humping engines and wrong-way movements of engines returning from the sorting group are carried out under the control of the hump and tower operators working in conjuction with one another, and giving hand signals or verbal instructions as necessary to direct the enginemen. At Whitemoor (Up) yard, wireless communication is used to facilitate the movements of humping engines throughout the yard. At Toton (Up) yard the humping repeater signal on the side of the humping line opposite to the hump building is double sided in order to enable men employed in and about the sorting group to see when and which humping aspects are displayed.

In British yards equipped with power-operated points, the panels are arranged to shew track layout in the switching area and the indications thereon contribute to the safety of yard operations, particularly in fog.

Klaxon horns, electric bells and loud speakers are provided at most large yards for giving audible signals in emergencies, or when adverse weather conditions preclude the use of the normal visual method of signalling.

F. — Communications.

Both in Great Britain and the U. S. A. there have been important developments in yard communication systems, but the methods do not involve any basic principles which were not known at the time of the 1930 Congress.

During the last ten years equipment for inductive communication and wireless has been made available in a form suitable for use on engines, and in the U. S. A. since 1945 a large number of yards have been so equipped. In Great Britain, one wireless installation has been in service three years, and other installations are in the experimental stage.

One-way and two-way loudspeaker systems of improved design have been provided in many yards, and recently several installations of the talk-back type have been made. The latter type of equipment enables the ground staff not only to receive messages, but to reply when necessary without having to move close to the microphone unit. With either of these loudspeaker systems, the operator at the control point may be able to call individually any one unit in the yard, and many recent American installations include separate « paging » equipment consisting of groups of high powered one-way loudspeakers distributed throughout the yard, mainly for the purpose of instructing individual members of the ground staff to communicate with the control point.

The use of teleprinters has been developed in both countries and extensive pneumatic tube installations are provided in many American yards.

British yards.

In British yards telephonic communication is provided between the yardmaster, supervisory staff at « key » points, hump and control tower staff, signalmen at inlet and outlet, maintenance staff, etc. The types in use are either automatic or on the « omnibus » circuit principle with code and in some instances selective ringing.

Telephone circuits connected to the railway exchange located at convenient points such as the yardmaster's office or passenger station are provided where necessary so that communication can be established with points outside the yard area. Circuits to the district traffic control offices are provided giving direct communication with signal boxes, the yardmaster's office, and elsewhere as necessary for the purpose of train and traffic regulation.

Two-way loud speaker installations have been provided at all the retarder yards between the hump building and the control tower, for announcing the commencement of humping, for varying the speed of humping, for regulating movements of engines, etc.

At Toton (Up and Down) yards two-way loudspeaker communication is also provided between the control tower and the point area, and between the inlet signalbox and the hump building. At Toton (Up) yard a more extensive two-way loudspeaker installation is provided giving communication between all the « key » points throughout the yard. Projection type speakers mounted 12 to 14 ft. high are used at outside locations and the reply microphones with speak keys are placed at suitable points in the fans. Cabinet speakers and wall or table microphones are provided at inside locations, and where selection on a number of different channels is required, switch cabinets are fitted.

At Mottram yard, « cut » numbers are transmitted from the uncoupling area (in the vicinity of the converging point of the reception lines) to the point operators' cabin, by a loudspeaker system. Alongside the track where the vehicles are uncoupled are several microphones in series — one or other of which picks up the voice of the uncoupler announcing the cuts from a reasonable distance without it being necessary for him to speak at close range. It will be understood that this man cannot stand in one fixed position, and moves backwards and forwards varying distances determined by the length of the particular « cut ».

In the North Eastern Region of British Railways an experimental talk-back loudspeaker system has been installed. The outside loudspeakers can be key selected. They are of the high pressure cone re-entrant 15 W type, the inside or control room speaker being a standard 6″ or 8″ cone type. The amplifier used has two units, one for the outgoing speakers (15 W) and the other for the incoming reproduction (3 W). Excessive noise level « squelch » is applied on incoming signals.

One-way loudspeaker systems are used at Hull (Inward) and Whitemoor (Up and Down) yards for communication between the control tower staff and the shunters. At Hull, six 15 W units are located adjacent to the retarders.

No special facilities have been reported for communication between the yardmaster and the staff at the various key points other than the telephone systems described above.

No special means are reported for the transmission of waybills, invoices, train lists, etc., in Great Britain, where the necessity does not arise to the same extent as in the U. S. A.

At Whitemoor (Up) yard, two-way simplex wireless communication (85.4 megacycles per sec.) is provided between the control tower, hump and the diesel-electric engines regularly used on humping duties. On the engines and at the control tower, both receivers and transmitters are accommodated. At the hump, receiving and transmitting facilities are provided by means of a unit for remote control of the apparatus located in the control tower.

On the London Midland Region of British Railways, an experimental two-way wireless installation has recently been installed in one yard, to provide communication between the foreman's office and a diesel-electric engine. The system is simplex and operates on 160 megacycles per sec.

On the North Eastern Region of British Railways a short wave wireless equipment for providing communication is being installed between a control tower and a shunting engine. The apparatus is simplex and operates at 80.025 megacycles per sec. and crystal controlled F. M. at 20 W R. F. Experimental equipment for the same purpose, on a two-way inductive system is being tested by this Region. The apparatus will function at 12 kilo-cycles per sec. and is simplex and F. M. 30 to 40 W R. F. are required for the mobile transmitter and 2 to 6 W R. F. for the control tower set. Adjacent pole routes are used for the antennae.

An American type of wireless set has been installed at Moghalsarai (Indian Railways) for communication with the shunting engine drivers, the equipment works on a frequency of 159 megacycles per sec.

American Yards.

North Platte yard (Union Pacific Railroad), the layout of which is illustrated diagrammatically in Fig. 4, is provided with the various systems of communication which are briefly described in *a*) to *d*) below, to indicate the type of equipment provided in modern American retarder yards. The yardmaster in charge of humping operations has his office on the second floor of the cabin at the apex, and the lower floor of the cabin is occupied by the foreman of the humping crew. Control tower « A » controls the first three points and the first three retarders; towers « B » and « C » each control 19 points and three retarders. The general yardmaster's office is located on an upper floor of a building near the outlet end of the sorting group.

a) *Teleprinters.*

Cut lists are received in the general telegraph office on a reperforating tape, which is run through a transmitter operating teleprinters in the two yardmasters' offices and the three control towers.

b) *Telephones.*

A 55 line PBX telephone switchboard is provided in the general yardmaster's office for local and long distance communication.

c) *Wireless communication.*

Two fixed stations are provided, one at the general yardmaster's office (160.29 megacycles per sec.) and the other at the cabin on the hump (160.41 megacycles per sec.). On each of the eight diesel locomotives employed in this yard, two receivers and one multiple frequency transmitter are installed. This apparatus requires a 117 D. C. supply, the current being provided by means of a motor generator set driven from the 64 volt engine starting battery at 117 volt A. C. and rectified by selenium power packs.

The engineman communicates with the foreman in the hump building while humping, and when employed elsewhere in the yard he keeps in touch with the general yardmaster — the frequency of his transmitter being changed by operating a thumb switch in the cab. The volume of the loudspeaker in the cab is controlled by a knob located near the thumb switch for selecting frequencies.

The wireless controls are on the ground floor of the hump building and are duplicated in the yardmaster's office on the floor above, so that he can communicate with the engine crew when it is on the reception lines, etc.

d) *Loudspeaker communication.*

Two systems are provided. The principal system is for communication between the general yardmaster and the men at various places throughout the yard, and the secondary system is for communication between the hump building, the three control towers, and the men at the apex and in the sorting sidings.

The general yardmaster, by operating the appropriate key on his switchboard, can speak to any one of 120 talk-back loudspeakers fixed back-to-back on posts 7 ft.

high spaced 200 to 300 ft. apart. For speaking, the yardmaster presses a foot switch, which he releases for listening, and he can be heard and answered by the man on the ground provided he happens to be within 100 ft. of one of the loudspeaker units, which are rated at 35 W (peak). If the man being called does not answer, then the yardmaster operates a key to connect his microphone to any one of four groups of « paging » loudspeakers. These are located on poles 50 ft. high 800 to 900 ft. apart and are rated at 50 W.

The positions of the various types of loudspeaker are indicated on the diagram of North Platte yard, — Fig. 4.

When it is desired to call the yardmaster, a button is pressed on the post at a talk-back location. In the general yardmaster's office a buzzer sounds and a lamp adjacent to the key corresponding to that location, is lighted. The yardmaster then operates a key and foot switch to speak.

The secondary loudspeaker system is similarly operated, either by the foreman of the engine crew from the ground floor of the hump building, or by the hump yardmaster from his office on the upper floor. It consists of 12 talk-back locations in the control towers, in the vehicle inspection pit, and among the sidings. In addition, there are five high powered one-way speakers for giving general instructions to men uncoupling vehicles, etc.

Each key on the switchboards applies to two loudspeaker locations — one in the « up » position and the other in the « down » position, and there is an indicator light corresponding to each location. The microphone and loudspeaker at each switchboard are common to the loudspeaker systems and wireless communications, and there are knobs for volume control of the wireless and loudspeakers.

Pneumatic tubes.

At Whitemoor (Up and Down) yards and at Hull (Inward) yard, pneumatic tubes are used to convey copies of the « cut » lists from the hump to the control tower.

In the U. S. A., more extensive use is made of this equipment, particularly for transmitting waybills and other documents from the inlet of the yard to the yardmaster's office, where the « cut » lists and waybills for outgoing trains are usually prepared. Owing to the great length of many American yards, the lengths of the principal tubes may be very considerable. In one recent installation, 18 400 ft. of 5 ½ in. diameter aluminium alloy tube was used, one route alone being 7 200 ft. in length.

Tube 4 to 5 ½ in. diameter is used in other yards for main routes, and for subsidiary routes to icing tracks, control towers, etc., 2 1/2 to 3 in. diameter tube is provided. Messages by pneumatic tube are transmitted at a speed of 20 to 30 m. p. h.

Various communication systems.

a) *Communication with shunting engines.*

The inductive type communication system is installed in some American yards, for example in Enola yard, in order to provide communication with the shunting engines. Either one-way or two-way systems may be used.

The equipment on the engine includes coils which pick up high frequency carrier currents usually transmitted from the hump building. Distribution of these currents is effected by bonding some of the rails and by antennae carried on poles or buried underground parallel to the sidings where the engines work. When the engine is under the control of the hump operator, a green light is normally illuminated in the cab, but when a message is about to be transmitted, or failure occurs, the light changes to red and a buzzer sounds. In the one-way system, acknowledgement of a message is usually made by the whistle or by the headlight, or by immediate compliance with the instruction.

The various areas of the yard can be controlled separately by using different frequencies, which may also be chosen to avoid interference with adjoining installations.

The inductive system does not require a licence, which is an advantage when the authorities are unable to allocate frequencies suitable for railway purposes.

b) *Facilities for number-taking.*

In the U. S. A., there have been some interesting experiments in this connection.

At Argentine yard (Santa Fe Railroad), portable wireless (receiving and transmitting) sets are used by staff in the reception and departure groups for transmitting vehicle numbers to the yardmaster's office.

At Cedar Hill yard (New York, New Haven and Hartford Railroad) the numbers of outbound vehicles are read direct off the vehicles into a microphone connected to a disc type recording unit, located some distance away in the yardmaster's office. When no numbers are being transmitted, the recording unit does not operate, so that a continuous recording is obtained on the disc. The recording is played back through earphones to the staff responsible for making up waybills. Thus, time is not occupied at the yard in preparing and transmitting information to the yardmaster's office, and detailed particulars of the vehicles can be provided without an excessive amount of writing out-of-doors, which, in bad weather, is difficult to carry out with clarity and accuracy.

G. — Lighting.

The design of the lighting installation of a marshalling yard is a matter which should be considered at an early stage in the preparation of the scheme, so that the best possible locations for poles, towers, cable routes, etc., can be reserved. Experience in recent years in Great Britain and in the U. S. A. indicates that in these circumstances the cost of providing an ample degree of illumination is small in relation to the cost of the scheme as a whole and to the greater speed and safety of night working which it makes possible. It is, however, now generally realised that the mere measurement of the degree of illumination is not the sole criterion and that other matters must be taken into consideration such as :—

a) Nature of object which it is desired to illuminate, for example, shape, colour contrast, texture of surface, speed of movement, etc.

b) Effectiveness of illumination as a whole, as judged by the visibility of distant objects, absence of shadows, psychological effect, etc.

c) Atmospheric conditions — for example fog and smoke.

Illumination values at ground level.

Bearing in mind the above remarks, illumination values for British and American yards are quoted in the table on the following page.

Typical American values of illumination quoted by Pennsylvania Railroad are :—

POSITION	MINIMUM ILLUMINATION RECOMMENDED Lumens per square foot of area lighted
Reception and Departure Groups	.05 to .10
Sorting Group	.10 to .20
At retarders	.20 to .50
Switching area	.10 to .30

It is reported that in recent installations the above American values are generally exceeded by 50 % to 100 % in accordance with the present day tendency to adopt a higher degree of illumination.

At Willard and Cumberland yards (Baltimore and Ohio Railroad) the values of

POSITION	MINIMUM ILLUMINATION PROVIDED (in foot candles) (1) AT GROUND LEVEL			
	Generally adopted in British yards	Provided during years 1930 to 1939		
		Mottram	Whitemoor (Up)	Whitemoor (Down)
Approach to hump . . . . Top of hump . . . . At retarders . . . . Between apex and farthest clearance point	1.50	Varies from .50 at base of pole to .05 between poles	Varies from 1.10 at base of pole to .05 between poles	Varies from .90 at base of pole to .11 between poles
Walking ways and frequented areas between tracks in sorting sidings	.25	Varies as above from .40 to .05	Varies as above from .70 to .05	As above

(1) Note : — Full moonlight at ground level is .03 foot-candles.)

illumination provided between the apex and clearance points and throughout the sorting sidings are 2.00 to 3.00, and .30 to .40 ft. candles, respectively. At Pocatello yard (Union Pacific Railroad) the corresponding values are .50, and .10 to .20, respectively. Both these yards are primarily illuminated by floodlighting.

No useful comparison can be made between the values of illumination provided in the various yards as requirements may vary in each case, for example :—

a) The amount of night work may not justify an elaborate lighting installation.

b) Extent to which it is necessary to observe the speed of vehicles and the state of occupation of each track.

c) Method of local illumination required for number taking and for vehicle examination, methode of indicating destination of cut, etc.

Thus the design of the lighting installation should take into account the method of working the yard as well as the considerations mentioned in the opening remarks. In addition, it is difficult to compare a floodlighting installation with an installation consisting of individual lights, having regard to varying climatic and site conditions.

Types of lighting.

In the majority of yards on British Railways the lighting usually consists of individual lights comprising 200 to 500 W tungsten filament lamps in enamelled iron dispersive reflectors, giving a cut-off of approximately 20° below horizontal. The fittings are usually mounted on poles 25 to 35 ft. above rail level and spaced to give the degree of illumination required at the location, due care being taken to ensure that there is sufficient clearance between the poles and the track to enable a man to pass with safety.

A low mounting height minimises the effect of fog and additional lights as low as 10 ft. may be required in certain positions. At Toton (Up and Down) yards, lights are provided near ground level at the retarders to reveal vehicles in silhouette to assist the brake operator during dense fog.

At the time of the 1930 Congress, floodlighting by means of horizontal projector lanterns with 500 to 1,000 W lamps mounted at 40 to 50 ft. was installed in some British yards. This form of lighting has not developed in Great Britain for the following reasons :—

a) Fog is liable to occur in many districts.

b) Glare, shadows, and an uneven distribution of light are caused.

Floodlights are now reported only as being used where there is insufficient space for individual lighting points. For example, at Toton (Down) yard a pylon 100 ft. high carrying four 1,000 W floodlighting units is provided in order to cover part of the yard. At Hull (Inward) yard floodlights with beams directed obliquely or downwards are used at the head of the sorting group.

Experiments have recently been carried out by British Railways (Southern Region) with dispersive type lighting units providing illumination in all directions below the horizontal and mounted 100 to 150 ft. above rail level. This method gave a good quality of lighting and a uniform general illumination at ground level, but experience has not yet been obtained with this method of lighting under varying site and climatic conditions.

In 1946 consideration was given by British Railways (Eastern Region) to lighting the whole of one yard in the London area by means of a few high units. Wooden poles, spaced 300 ft. apart and affording a mounting height of 50 ft., were each fitted with three prismatic diffusing globes carried on brackets at 120° spacing. Each globe contains a 400 W mercury vapour lamp, except that near signals, the same type of globe is equipped with a 750 W tungsten filament lamp, giving approximately the same light output. Raising and lowering gear is provided to facilitate maintenance, and cables are run underground. It is reported that the general lighting effect, which is similar to full moonlight but of greater intensity, is satisfactory and that the average illumination at ground level is .25 ft. candles.

In the U. S. A. the majority of retarder yards are equipped with floodlighting units supported by towers 80 to 110 ft. high. For example, at Willard yard, there are twelve 100 ft. towers fitted with 1,000 W units as follows :— two with 14 units each, three having 10, 9 and 8 units, two having 6 units, and two having 4 units, and three having 7 units. At this yard, the floodlights are operated from the control tower, or they can be controlled automatically by photo-electric devices on the towers. At Pocatello yard, five 100 ft. towers, fitted with nine or ten 1,500 W units, are provided.

The Pennsylvania Railroad do not adopt individual lights for the following reasons :—

a) Lack of range.

b) Lack of space between tracks.

c) Higher cost of installation and maintenance.

In the U. S. A. it would appear that fogs are generally not so prevalent as in Great Britain.

The reply received from the Indian Railway Board indicates that floodlight towers 90 to 150 ft. high are used in some Indian yards, the units being of 1,000 to 1,500 W capacity. For installations with individual lights 300 to 500 W lamps in dispersive reflectors, spaced 150 to 200 ft. apart, are used. The value of illumination varies between .06 and 3.50 ft.-candles.

H. — Buildings.

In a retarder yard it is necessary to provide certain buildings of a special character in addition to the accommodation required for normal yard staff.

At British retarder yards there are usually two such special buildings, namely a control tower near the retarders and a building near the hump. It is from these that control of humping operations is exercised, co-ordination being usually effected by a yard inspector on each turn of duty who may be responsible to the yardmaster or an assistant yardmaster for the whole of the working of the yard, or only for the supervision of operations at the incoming end and in connection with the hump shunting. A separate inspector or foreman may be held responsible for the outgoing end, including subsidiary shunting or marshalling. The organisation is,

of course, arranged to suit different conditions.

Accommodation for staff employed elsewhere than in special hump buildings and control towers is provided at convenient points, taking into account the desirability of :—

a) being adjacent to where their duties are performed;

b) combining the various requirements into as few buildings as possible.

The former reduces walking and other unproductive time to a minimum and the latter permits of more economical planning and construction of buildings, provision of central heating and messing facilities, etc. The buildings are usually constructed in brickwork, with flat roofs.

Since the 1930 Congress, in yards where point operation is carried out from the hump, it has been necessary to develop the design of a hump building suitable for this purpose. The more recent control towers in British yards are of improved design, and are planned to accommodate hydraulic retarder machinery, electrical apparatus and maintenance staff in addition to the facilities required by the operators. Figs. 13 and 16 illustrate typical modern buildings at Toton (Down) and Hull (Inward) yards respectively.

In the U. S. A. the design of control towers has been developed on modern lines and in some recent yards the design of the hump building is now more elaborate and provides accommodation for the hump yardmaster on an upper floor, so that he can overlook the reception group and switching area when using his loudspeaker and wireless communications.

The yardmaster's office in Great Britain is sited at a point convenient for general operating purposes, and having regard to liaison with other departments. As far as possible, all administrative and clerical work is concentrated in this office, and the principal messrooms, stores, etc., may be included in the same block. It is possible to provide accommodation for tools, lamps, etc., in the control tower, hump buildings, or in the groups of buildings at other positions in the yard.

Fig. 15. — East St. Louis Yard Alton and Southern R. R. U. S. A. — Communications tower for supervisor.

In the U. S. A., however, the general yardmaster's office is generally connected by a pneumatic tube system to key points in the yard, and by loudspeaker and wireless with the control towers, hump buildings,

engines, etc. In some recent yards it has therefore been advantageous to provide the yardmaster with a control room situated on an upper floor of the building and commanding a view over the whole yard.

Another development has been the provision of inspection pits from which the undersides of vehicles can be examined as they move towards the hump. These pits are equipped with special glazing, lighting, and safety devices, and with two-way communication with the hump building and in some cases with vehicle repair staff.

Control towers.

Control towers at the recent British yards are similar in appearance and designed to provide accommodation for staff working at the retarders and in the switching area. For example, at Toton (Up) yard the control tower contains the following (the bracketted figures give dimensions in feet) :—

Ground floor (128 × 30).

Mechanical fitters' workshop and store (20 × 30).

Hydraulic machinery room (40 × 30).

Air cooling plant (15 × 7).

Shunters' mess room (10 × 12).

Mechanical and signal fitters' mess room (9 × 12).

Electrical equipment room (40 × 15).

Compressor plant for point machines (22 × 15).

Signal fitters' workshop (18 × 15).

Lavatory (3 × 6).

Boiler room (gas fired) (6 × 10).

First floor.

Relay room (26 × 16).

Fig. 16. — Hull (Inward) yard. — *British Railways* (N. E. Region).
Control tower and railbrakes.

Second floor.

Control room (26 × 16).
Lavatory, etc. (10 × 3).

At Hull (Inward) and Toton (Down) yard the towers were designed to house the weight operated accumulator.

In American retarder yards, the control towers are usually of brick construction and only house the point and brake operator and the necessary control apparatus, with a lavatory and boiler room. The site occupied varies from approximately 300 to 400 sq. ft. When it is necessary to give an unobstructed view, the tower is generally supported on columns.

In some American yards not equipped with retarders, towers 45 to 65 ft. high are provided for the use of the yardmaster or his assistants; these are of steel frame sheeted construction, and are used for directing yard operations by means of wireless and loudspeaker communication systems, — Fig. 15.

Hump buildings.

In the British retarder yards where point operation is controlled from a tower in the switching area, the hump cabin is only required as an office for the man in charge of humping operations, and shelter for outdoor staff. At Toton (Up and Down) yards, however, it is necessary that the buildings should be primarily designed to house the operating panel, and the principal requirements of the design are that the operator must be able to observe :—

a) The chalked numbers on the vehicles indicating the siding for which they are to be routed, under all weather conditions and at night time.

b) The separation of the cuts at the apex and on the steep initial gradient.

The main feature of the design is, therefore, a large bay window of adequate projection and length. The hump building is situated opposite the apex of the hump and the panel is positioned at an angle of about 45 degrees in relation to the humping line and facing the reception lines. This has been found from experience to facilitate operation of buttons, switches, etc., whilst at the same time affording the operator uninterrupted vision throughout an area embracing the reception lines, retarders and switching area. The hump building at Toton (Up) yard, for example, occupies a site 42 ft. by 38 ft. over-all and contains the following :—

Control room (excluding projection) (30 ft. × 10 ft.).

Inspector's office (10 ft. × 12 ft.).

Shunters' shelter (5 ft. × 7 ft.).

Relay room (20 ft. × 15 ft.).

Locker room with access to lavatory and boiler compartments (10 ft. × 15 ft.).

The projection of the control room measures 10 ft. × 13 ft. long and the window is 9 ft. from the nearest rail.

Where route-setting together with transmission of « cut » information are initiated from the hump, the primary consideration in siting the hump building and in designing the operating room, is the position in relation to the hump from wich the operator can best see the chalked numbers on the ends of approaching vehicles and the point of separation of cuts of varying lengths.

When this position, with that of the operating panel, has been decided, an adequately glazed « bay » window facing the hump line can be planned to give the operator visibility through an arc of at least 180 degrees. The completion of the designing of the remainder of the operating room and the rest of the building is a comparatively simple matter.

As stated in the previous section, in some recent American retarder yards two-storey hump buildings provide accommodation for the hump yardmaster who then has a wide view over the yard, and can issue instructions to the staff in the area under his control by means of loudspeaker and wireless communication.

GENERAL.

We have made specific reference in this report to various sources of information outside the actual railway administrations in Great Britain and the U. S. A. To these, also to « The Railway Gazette » (England), several of whose published illustrations we have taken the liberty of including, and to « Modern Transport » (England), we express our thanks for information which has been of assistance to us in compiling our report.

SUMMARY OF CONCLUSIONS.

1. During the last twenty years there have been important developments in the methods adopted for the design and construction of marshalling yards.
2. There is a growing tendency to replace manual effort by « mechanisation », particularly in the case of large yards.
3. The opportunities for constructing new yards are frequently restricted due to physical considerations, but the possibility of doing so by taking over the work performed by several smaller yards continues.
4. There are many old yards which are inefficient by reason of their out-of-date design, but remodelling and modernisation present difficulty due to economic and financial considerations.
5. Greater attention is being paid to fundamental principles, also to detailed design and equipment, in order to increase efficiency and reduce construction, maintenance and operating costs.
6. In all aspects of new design and construction, it is essential that there should be the fullest consultation and co-operation between the departments affected at all stages and at all levels.
7. As the department responsible for « operations » is the one which normally has to justify schemes intended to facilitate the efficient working of traffic, it is desirable that the Operating Department should advance the preparation of a scheme to the extent practicable before the Engineering Departments commence work on any plans or estimates.
8. All aspects of yard operating performance, together with study of developments generally, also close contact with Engineering Departments, should be handled by experienced staff within the Operating Department who should specialise on this feature where not already done.
9. Each instance of new construction or remodelling constitutes an individual economic operating and engineering problem.
10. Double direction yards can be designed economically where a combined flow of traffic will be within the capacity of the yard.
11. Any layout provided for brakevan movements, for release of train engines, for by-passing the hump, etc., should not unduly increase the distance through which trains are required to travel when moving slowly towards the apex for humping.
12. Where a separate engine release line is incorporated the lead should be on the steep initial gradient of the hump, provided that train engines can negotiate the vertical curve at the apex.
13. A separate track should be provided for the humping engine to return to the rear of trains, and for drawing shunts out of the sorting group. This track should terminate in a dead end spur at the inlet end of the yard, and the layout at this point should be such that trains can be accepted into the reception group at all times.
14. Two humping lines are not required in order to give continuity to shunting operations; the provision of cross-overs between two such lines increases the length of the layout between the reception lines and the hump.

15. It is not necessary to provide two humps, one for « Summer » and one for « Winter », in a retarder yard.

16. Minimum spacing between tracks is generally adopted for the sorting group in order to give a compact layout at the head of the group and to obtain maximum capacity. Wider spacing is required adjacent to running lines, for vehicle repair tracks and where lighting poles occur, etc.

17. The use of « tandem » or « three-throw » leads may be justified at the head of the sorting group to give the most compact layout possible.

18. The use of new permanent way material of main line standards is justified at the head of the sorting group, on the humping lines, and at other key points in the marshalling yard.

19. A drainage system is required to cover the whole yard area. An adequate depth of ash ballast is essential, and where track circuiting occurs, special drainage and ballasting are necessary.

20. By the use of modern mechanical plant, schemes involving heavy earthworks may not prove too costly.

21. A completely gravitational yard may be economical in special cases provided that site conditions are favourable. If a large throughput is desired, it may be found that the gravitational system is too slow in operation and requires an excessive number of ground staff. No instance has been reported of retarders having been provided at such yards.

22. A hump yard can be constructed on most normal sites where space is available, and where there are few obstructions which pre-determine the levels. The longitudinal profile is subject to definite requirements between the hump and the clearance points in the sorting group. The remainder of the profile, i.e. between the entrance to the yard and the hump, and between the clearance points and the exit from the yard, can be adjusted within reasonable limits.

23. It is desirable that the distance between the hump apex and the farthest clearance point in the sorting sidings should be kept to a minimum, consistent with the provision of suitable curvature and crossing work, in order to reduce the height of hump and to facilitate separation of cuts.

24. On the approach side of the apex the gradient should rise sufficiently to facilitate the uncoupling of vehicles.

25. The vertical curvature at the hump apex should be designed to give quick separation of cuts, particularly at retarder yards, taking into consideration the working of engines and vehicles in general use over the hump.

26. A short length of level track at the apex may reduce the number of types of engine and vehicles prohibited from working over a vertical curve of small radius.

27. A steep initial gradient is required to accelerate vehicles quickly, and to ensure proper separation having regard to their different running characteristics.

28. After this steep initial gradient and as far as the leaving end of the retarders, gradients are provided which will enable vehicles which may be stopped in the retarders, to gravitate into the switching area.

29. Beyond the retarders non-accelerating gradients should be provided through the switching area and as far into the sorting sidings as necessary.

30. The speed of humping is largely governed by the running of vehicles beyond the retarders and it is therefore necessary that the most suitable profile should be provided in the switching area.

31. At the outgoing end of the sorting group, the sidings should be levelled out, or a rising gradient provided, to

prevent good running vehicles over-running the clearance points.

32. No new basic principles for retarding vehicles have been introduced but developments in retarder design have taken place. The hydraulic type is in use in Great Britain and India. In the U. S. A. the electro-pneumatic and all-electric types are installed.

33. Hydraulic retarders in recent yards are placed on specially designed inspection pits connected by a subway in order to facilitate maintenance. An electro-pneumatic retarder has been developed having the working parts above ballast level.

34. There is a tendency towards the extension of automatic control of point movement at hump yards with or without retarders. The systems are either fully or semi-automatic, i.e. the route being set throughout, or only to a partial extent, point movement being controlled by track circuit.

35. The control of fully and semi-automatic point movement should be effected from a tower located to one side of the switching area, or from a specially designed hump building, — non-automatic points being operated by switch operation in the tower. For both systems, provision should be made for non-automatic working of all points from the tower.

36. Storage of point movements for the various cuts is not carried out before humping commences, in the case of some recent installations. When fully or semi-automatic point control is effected from the hump building, « storage » for about eight cuts is provided and the appropriate route buttons are depressed as vehicles pass the apex. A system of progression relays continues the control of point movements for cuts already in the track circuited switching area.

37. Advance preparation of « cut » lists is not necessary at yards where fully and semi-automatic point operation is carried out from a hump building, provided facilities are available for the operator to observe the chalked siding number on the leading end of an approaching cut, and for transmitting the siding number and cut particulars to the point and brake operators in the control tower.

38. Transmission of siding and cut numbers in two recent installations is effected after both the route and cut buttons in the hump building are depressed, and this information is printed on bands of paper at the operators' positions in the towers as the cuts pass over the hump.

39. « Cut » lists are used where point operation is carried out from control towers adjacent to the switching areas. In some British yards pneumatic tubes are used to transmit them from the hump to the tower before humping commences. In American yards, trainmen's lists are generally conveyed by pneumatic tube from the yard inlet to the yardmaster's office, where « cut » lists are prepared, and transmitted to the towers and hump by teleprinter or pneumatic tube. If train lists are sent ahead by teleprinter, reperforating tapes may be used to repeat « cut » information to key points in the yard.

40. Humping signals, giving at least three aspects i.e. « stop », « hump slow », and « hump normal » or « hump fast », are usually provided. The signals may be of the semaphore, colour-light, or position-light type, repeated as necessary according to local conditions. In a recent installation, the reception group was designed with space between alternate tracks for lunar-white three-aspect position-light humping signals in series, with applicability indication, thereby giving the engine driver uninterrupted vision at all times during a humping movement

of the signal and aspect he is required to observe.

41. There have been extensive developments of one-way and two way loud speaker communication between « key » points. Talk-back systems are used in some instances to enable ground staff to send messages without speaking close to a microphone. For the purpose of attracting attention of individual members of the ground staff, or for the issue of general instructions, « paging » systems have been developed.

42. Wireless communication is extensively used particularly for controlling the movements of shunting engines in the U. S. A.

43. Yard lighting continues to receive attention and the tendency is to provide illumination of greater intensity and improved quality.

44. Special buildings are provided at retarder yards for accommodating point and brake operators and, having regard to the concentrated nature of their work, the siting and designing requires careful consideration in order to ensure that their position is the most suitable to enable them to carry out their duties in the most efficient manner.

45. Towers of various forms of construction are provided, usually at the outer side of the railbrake and point area, and of sufficient elevation to ensure an adequate range of visibility.

46. A suitable building is necessary in the vicinity of the hump and if route-setting combined with transmission of cut information is performed from the hump, a specially designed bay window is incorporated.

47. Greater attention is now paid to combining other staff accommodation into blocks so as to facilitate construction, maintenance, provision of central heating and staff amenities.

48. The location of accommodation for the yardmaster and supervisory staff generally is important. At some recent U. S. A. yards, one or other of the buildings has an upper storey, equipped with communications, in order that supervisors can overlook areas under their control. In some non-retarder yards in the U. S. A., towers 45 to 65 ft. high have been constructed in a commanding position, and similarly equipped, for the sole use of supervisors.

SUPPLEMENTARY.

Since this Report was compiled, information has been received from the South African Railways and Harbours administration.

At Prospect (Johannesburg) a double direction type yard with one hump is being constructed to replace a number of smaller yards. The following groups of sidings will be provided, for an estimated throughput of 2,000 to 2,300 vehicles per day :—

Reception : 9 sidings (4 west, 5 east) with six additional for serving the marshalling group;

Sorting : 32 sidings in 4 fans;

Departure : 8 sidings (4 eastbound, 4 westbound);

Marshalling : 16 sidings.

The marshalling group is situated to the north of and between the reception and sorting groups, and is fed with vehicles drawn from the outgoing end of the northernmost fan of the sorting group.

Five electro-pneumatic retarders are being provided, one before the « king » points at the lower end of the steep initial gradient, and one for each fan of sorting sidings between the « queen » and « jack » points. A control tower is sited to one side of the switching area near the « queen » points.

The profile is similar to those adopted in British yards i.e., 1 in 18 initial gradient

followed by 1 in 60 as far as the leaving end of the retarders. Beyond the retarders the gradient is 1 in 200 for 600 ft. into the sorting group. On the approach side of the apex, there is a rising gradient of 1 in 69 connected by a vertical curve 132 ft. long (1,900 ft. radius) to the 1 in 18 gradient.

The following further details have been reported :—

Gauge : 3′ 6″;
Width of goods vehicles : 8′ 3″;

Space between tracks (normal) : 13′ 0″ centres;

Space between tracks (where electrification masts) : 14′ 0″ centres;

Minimum radius of track curvature : 500 ft.;

Crossings : 1 in 9, or 1 in 12;
Rail : 80-lb per yard.

The yard is located to one side of the two main lines, and a bridge carries the East arrival line over the West departure line.

APPENDIX « A »

Response to questionnaire.

ADMINISTRATION	No reply received up to 20.1.50	Reply received		
		Unable to undertake compilation	No large or modern yards or not affected	Detailed reply received
Argentine	×			
Burma		×		
Brazil, Est	×			
» Rio Grande	×			
China	×			
Costa Rica	×			
Egypt, Etat	×			
» Delta Light	×			
U. S. A., Bessemer and L.E.	×			
» Delaware and H.	×			
» Long Island	×			
» Pennsylvania				×
Great Britain, British Railways				×
» London Transport			×	
East African			×	
Nigerian		×		
South African				×
Sudan			×	
Ceylon			×	
India				×
H. E. H. the Nizam's			×	
Malayan	×			
Victorian			×	
New Zealand	×			
Iraq		×		
Iran	×			

Large yards const

COUNTRY	GR				
MARSHALLING YARD	Whitemoor Up	Whitemoor Down	Hull Inward	Mottram	Toton Up
Peak — 24 hour period :					
1. Number of vehicles received	3 850	3 000	2 750	2 750	3 500
2. Number of trains received and shunted	69	52	56	69	60
3. Maximum rate of reception of trains i. e. number of trains arriving during a peak period of say four hours	18	14	14	16	12
4. Total number of trains despatched after shunting :					
(a) rough (unmarshalled)	—	—	63	59	60
(b) in marshalled order of destination or direction	—	—	—	—	—
5. Number of trains despatched from separate departure group (if one exists)	—	—	9	—	—
6. Number of trains stopping at yard to attach or detach vehicles	—	—	—	—	—
Average — 24 hour period :					
1. Number of vehicles received	2 950	2 550	2 300	2 200	3 000
2. Number of trains received and shunted	55	45	51	58	55
3. (See 3 above).					
4. Total number of trains despatched after shunting :					
(a) rough (unmarshalled)	38	—	53	56	54
(b) in marshalled order of destination or direction	16	—	—	—	—
5. Number of trains despatched from separate departure group (if one exists)	3	—	9	—	—
6. Number of trains stopping at yard to attach or detach vehicles	—	—	—	—	—

(1) Other yards have been constructed or modernised during the last twenty years particularly in Ameri
but corresponding information in respect of these is not available.

APPENDIX « B ».

ised during last twenty years

TAIN			INDIA						U.S.A. (1)
Up	Severn Tunnel Junc. Up	Severn Tunnel Junc. Down	Chitpur	Naihati	Moghalsarai Up	Moghalsarai Down	Ondal Up and Down	Tondiarpet	Enola Westbound
50 46	1 250 31	1 600 32	1 300 26	1 500 37	1 600 28	1 500 24	2 100 41	900 —	4 400 59
8	6	7	10	10	7	7	12	12	(3 370 cars over hump)
8	—	—	20	27	—	—	—	—	53
3	23	31	6	10	28	26	41	—	
	—	—	all	all	all	all	—	—	—
3	2	7	—	—	—	—	—	—	—
0 3	1 150 30	1 450 30	950 22	1 000 25	1 300 23	1 025 18	1 750 35	850 30	3 250 53 (3 050 cars over hump)
8	—	—	17	17	—	—	—	—	48
2	21	30	5	10	25	17	35	20	
	—	—	all	all	—	—	—	—	—
2	2	6	—	—	—	—	—	—	—

Selected large yards co

COUNTRY / MARSHALLING YARD	Whitemoor Up	Whitemoor Down	H Inv
Year opened or remodelled	1 929	1 933	1
Reception group :			
Number of sidings	10	10	
Capacity (vehicles)	860	640	
Sorting group :			
Number of sidings	40	41	
Capacity (vehicles)	3 760	3 940	2
Departure group :			
Number of sidings	11	Nil	
Capacity (vehicles)	980	Nil	
Sorting group :			
Distance — hump apex. to clearance (feet) :			
Longest	800	975	
Shortest	665	750	
Distance between track centres (feet and inches) :			
Normal	12′ 2″	12′ 2″	1
With lighting poles, etc.	16′ 2″	16′ 2″	1
Distance hump apex. to « King » switches (feet)	114	100	
Radius of curvature — minimum (feet)	330	396	
Radius of hump vertical curve (feet)	528	528	
Gradient (average) hump to farthest clearance :			
per cent	1.80	1.61	
1 in	55	62	
Gradient (initial) from hump :			
per cent	5.55	5.88	
1 in	18	17	
Retarders :			
Locations	4	2	
Aggregate length (feet)	300	150	
Position (between)	Queen and jack switches	King and queen switches	C ar sw
Type	Hydraulic	Hydraulic	Hy

Note (1) Average over-all lengths of normal British, Indian and U.S.A. vehicles are 21 feet, 25 feet and 45 feet respectively.
(2) Vehicle capacities given above do not take in account engines and brakevans.

APPENDIX « C ».

lernised during last

	GREAT BRITAIN					INDIA	U. S. A.
ram	Toton Up	Toton Down	Banbury Up	Severn Tunnel Jc. Up	Severn Tunnel Jc. Down	Naihati	Enola Westbound
5	1949/50	1939	1931	1939	1939	—	1945
8	10	3	6	4	4	—	16
40	830	210	410	220	260	—	1 720
20	37	34	17	21	19	—	35
00	2 830	2 420	1 220	1 170	1 090	—	3 550
1	Nil	Nil	Nil	Nil	Nil	—	Nil
1	Nil	Nil	Nil	Nil	Nil	—	Nil
)	910	835	560	Ladder	600	—	1 680
np	750	630	340	track	420	—	880
2″	11′ 2″	11′ 2″	13′ 2″	12′ 2″	12′ 2″	—	12′ 6″
2″	15′ 8″	—	16′ 8½″	16′ 8½″	16′ 8½″	—	—
-	120	124	55	105	45	—	250
2	462	462	528	528	528	—	470
-	660	660	—	—	—	—	2 110
-	1.35	1.85	1.10	—	1.47	—	1.31
-	74	54	91	—	68	—	76
-	5.00	5.55	—	—	—	—	3.93
-	20	18	—	—	—	—	25
1	4	4	Nil	Nil	Nil	2	10
-	248	248	—	—	—	—	808
-	Queen and jack switches	Queen and jack switches	—	—	—	King and queen switches	Before K.Q. and J. switches
-	Hydraulic	Hydraulic	—	—	—	Hydraulic	Electro-pneumatic.

[621 .337]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

15th. SESSION (ROME, 1950).

QUESTION VI.

Comparative study of the different types of transmission between motors and axles of electric locomotives, electric motor coaches and Diesel-electric railcars. — Effect on the track of the types of bogies and systems of motor suspension.

REPORT

(America (North and South), Burma, China, Egypt, Great Britain and North Ireland, Dominions, Protectorates and Colonies, India, Iran, Iraq, Malay States and Pakistan),

by W. S. Graff-Baker, B. Sc.,

Chief Mechanical Engineer (Railways), London Transport Executive.

Replies to the questionnaire have been received from :

London Transport Executive.
British Railways Executive :
Southern Region,
Midland Region.
Eastern Region (Sections «A» and «B» only).
Victorian Government Railways.
Pennsylvania Railroad.

These replies cover the following types and numbers of vehicles :

1. Electric locomotives	234
2. Diesel-electric locomotives . .	365
3. Multiple unit electric motor cars	3336
4. Multiple unit diesel-electric motor cars	12
5. Diesel-electric rail cars. . . .	33
6. Diesel-electric shunting locomotives	428

***

1. Electric locomotives.

The use of electric locomotives is confined to the Pennsylvania Railroad and three locomotives on the Southern Region of British Railways. The majority of drives are by frame-mounted motors with a resilient quill drive, but the future trend of ideas is towards axle-hung motors on the score of simplification and reduced capital cost.

In order to improve the riding properties of the bogies, the Pennsylvania Railroad use swing bogie bolsters which are restrained by links which are inclined at an angle of 1 in 8. 44 of these locomotives have bogies which are coupled in the lateral plane but otherwise there is no corrective equipment to stabilise or improve the riding of the bogie.

2. Diesel-electric locomotives.

The answers for Diesel-electric locomo-

tives are confined to the Pennsylvania Railroad. The drive is by non-resilient straight spur gears from axle-hung traction motors. No change from this type of drive is anticipated as it is considered to be satisfactory from the point of view of riding, and simple and cheap in first cost.

The bogies have swing bolsters which are restrained by links inclined at an angle of 1 in 8 and on 12 locomotives the bogies are coupled in the lateral plane; otherwise there is no corrective equipment to improve the stability or riding of the bogie.

3. Multiple unit electric motor cars.

Multiple unit electric motor cars are in use on all the administrations considered, with the exception of the Ceylon Government Railways.

Axle-hung motors are in universal use and, with one exception, they have a non-resilient gear and pinion drive. The exception is the Pennsylvania Railroad, which uses a resilient gear and pinion drive, the resilience being obtained by the use of springs.

There is no likelihood of departure from this type of drive for rolling stock in the immediate future, on account of its simplicity, low capital cost and satisfactory riding properties.

All the bogies used have swing bolsters restrained by inclined links, the angle of which varies between 1 in 6 and 1 in 8; otherwise there are no devices to improve or stabilise the riding of the bogie.

4. Multiple unit Diesel-electric motor cars, and

5. Diesel-electric rail cars.

These vehicles are in use on the Pennsylvania Railroad and the Ceylon Government Railways. Only axle-hung motors with a non-resilient gear and pinion drive are used and there is no intention of departing from this arrangement in the future.

The bogies have swing bolsters restrained by links which are inclined at an angle of 1 in 8. No other devices are used to stabilise or improve the riding of the bogie.

6. Diesel-electric shunting locomotives.

Answers to this section of the questionnaire were given only by the Pennsylvania Railroad.

Axle-hung motors, with non-resilient gear and pinion drive, are used and it is intended to continue their use in future designs.

No stabilising devices are used, the bogie bolster being cast as an integral part of the bogie frame.

General.

There is little information — either observed or theoretical — regarding the effect on the track of the types of bogies and systems of motor suspension in use. Tests have been carried out on British Railways (Southern Region) to measure the dynamic loads at rail joints and on the Pennsylvania Railroad to measure the lateral forces on the rail but, in both cases, the results were restricted and could not be applied in a general form.

Conclusions.

Among the railways who replied to this questionnaire, there was universal agreement that the most satisfactory drive is by the nose-suspended axle-hung traction motor for speeds up to at least 120 km/h., on account of its simplicity, low capital cost and satisfactory riding properties.

The experience of the LondonTransport Executive has been that, by fitting one traction motor only in each bogie and so reducing the masses which cause lateral forces, the riding has been improved. In addition, the wear on the track, the severity of which is well-known for electric stock with two motors per bogie, is considerably reduced.

***

QUESTION 6.

Replies to the Questionnaire.

A. — GENERAL.

2. *Particulars of the gradients, curves and length of the lines over which the vehicles under consid*

ADMINISTRATION		Electric locomotives	Diesel electric lo
London Transport Executive	Maximum gradient.		
	Minimum curvature.		
	Longest run.		
	Total route mileage.		
British Railways (Southern Region)	Maximum gradient.	1 in 44	
	Minimum curvature.	100 m	
	Longest run.	—	
	Total route mileage.	—	
British Railways (Eastern Region)	Maximum gradient.		
	Minimum curvature.		
	Longest run.		
	Total route mileage.		
Ceylon Government Railways	Maximum gradient.		
	Minimum curvature.		
	Longest run.		
	Total route mileage.		
Pennsylvania Railroad	Maximum gradient.	1 in 74	1 in
	Minimum curvature.	140 m	140 m
	Longest run.	495 km	1853 km
	Total route mileage.	—	—
British Railways (London Midland Region)	Maximum gradient.		
	Minimum curvature.		
	Longest run.		
	Total route mileage.		
Victorian Government Railways	Maximum gradient.		
	Minimum curvature.		
	Longest run.		
	Total route mileage.		

iple unit electric motor cars	Multiple unit Diesel electric motor-cars	Diesel electric rail cars	Diesel electric shunters
1 in 29 68 m 49 km 230 km			
1 in 44 100 m — —			
1 in 50 — 51 km —			
	1 in 132 200 km — 149 km	1 in 132 200 m — 149 km	
1 in 45 — 189 km —		1 in 71 — 146 km —	— 75 m — —
1 in 91 — — 60 km			
1 in 40 120 m — 360 km			

3. *Loads and speeds in service for the various lines and different types of trains.*
4. *Gauge of the line.*
5. *In what year did you commence to put into regular service the vehicles concerned?*

ADMINISTRATION			Electric locomotives	Diesel electric locom
London Transport Executive	Maxim. load Maxim. speed Maxim. load Maxim. speed Gauge of line.	Tube stock. Surface stock.		
British Railways (Southern Region)	Maxim. load Maxim. speed Maxim. load Maxim. speed Gauge of line.	Passenger. Freight.	430 000 kg 106 km/h 1 016 000 kg 56 km/h 1 435 mm	
British Railways (Eastern Region)	Maximum load. Maximum speed. Gauge of line.			
Ceylon Government Railways	Maximum load. Maximum speed. Gauge of line.			
Pennsylvania Railroad	Maxim. load Maxim. speed Maxim. load Maxim. speed Gauge of line.	Passenger. Freight.	2 540 000 kg 129 km/h 5 700 000 kg 81 km/h 1 435 mm	Units 1 500, 2 0 122 km/h (3 000 Units 1 500, 2 0 82 km/h (3 00 1 435 m
British Railways (London Midland Region)	Maximum load. Maximum speed. Gauge of line.			
Victorian Government Railways	Maximum load Maximum speed Gauge of line.			

ltiple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
234 000 kg 89 km/h 356 000 kg 97 km/h 1 435 mm			
166 505 kg 88.5 km/h — — 1 435 mm			
— — 1 435 mm			
	66 km/h — 1 674 mm	66 km/h — 1 674 mm	
105 km/h 1 435 mm		97 km/h 1 435 mm	Up to 81 km/h 1 435 mm
600 kg (5-car train) 121 km/h 1 435 mm			
00 kg (7-car train) 84 km/h 1 600 mm			

6. *Principal characteristics of the vehicles considered.*

QUESTION	London Transport Executive	
	Tube stock	Surface stoc
1. Car builders	Birmingham Carriage and Wagon Co. Ltd. Metropolitan-Cammell Carriage and Wagon Co. Ltd.	Gloucester Rai Carriage and W Co. Ltd. Birmingham Ca and Wagon Co.
Electrical equipment	Crompton Parkinson Ltd. General Electric Co. British Thomson-Houston Co. Ltd.	Metropolitan Vi Electrical Co. General Electric
2. Designation	1938 tube stock	« O » and « P » s stock
4. Axle arrangement	1 — A + A — 1	A — 1 + 1 —
5. Date in service	1938	« O » stock 1 « P » stock 1
6. Number in service 1949	1 116	« O » stock 1 « P » stock 1
7. Total weight	27 840 kg	38 000 kg
8. Total adhesive weight	16 222 kg	22 740 kg
9. Total weight of mechanical parts	23 880 kg	27 420 kg
10. Total weight of electrical equipment	3 960 kg	8 580 kg (incl. me
11. Diameter of new motor wheels	78.6 cm	91.5 cm
12. Diameter of non-motored wheels	78.6 cm	91.5 cm
13. Type of axle bearing	Roller	Roller
14. Wheel balance	None	None
15. Type of brake	E. P. with retardation control, superimposed on automatic Westinghouse.	E. P. combined w adyne regenerat retardation cont erimposed on au Westinghouse.
16. Brake leverage	Motor axle 6.78 : 1 Idle axle 5 : 1	Motor axle 6.8 Idle axle 7.64
17. Braking of non-motored axles	Yes	Yes
18. Number of brake blocks per wheel	2 non-metallic	2 non-metal

British Railways — Southern Region		British Railways — Eastern Region	
ple unit electric motor cars	Electric locomotives	Tyneside stock	Liverpool St Shenfield stock
uthern region, itish railways	Southern region, British railways	Metropolitan-Cammell Carriage and Wagon Co. Ltd.	Metropolitan-Cammell Carriage and Wagon Co. Ltd.
ish Electric Co. opolitan Vickers trical Co. Ltd.	English Electric Co.	—	—
le Unit Suburban stock	Mixed traffic electric locomotive	—	—
Bo — 2	Co — Co	See drawing	Bo — Bo
1915	1941	1937	1949
1 073	3	64	92
142 247 kg	101 600 kg	56 261 kg	51 700 kg
55 472 kg	101 600 kg	24 384 kg	51 700 kg
106 815 kg	55 000 kg	48 082 kg	40 600 kg
35 432 kg	46 600 kg	7 270 kg	11 100 kg
109.2 cm	109.2 cm	109.2 cm	109.2 cm
109.2 cm	None	109.2 cm	None
Vhite metal	White metal	White metal	White metal
Both	None	Both	—
atic Westinghouse	Automatic Westinghouse	Westinghouse E. P.	Westinghouse E. P. with self-lapping control
5 : 1	5 : 1	6.8 : 1	—
Yes	No idle axles	Yes	No idle axles
2	2	2	2

6. *Principal characteristics of the vehicles considered* (continued).

QUESTION	London Transport Executive	
	Tube stock	Surface sto
19. 1 h./HP at motor shaft per motor	168 HP (BSS 173/1928)	152 HP (BSS 173/19
20. 1 h./HP at wheel treads per motor wheel . . .	164 HP	148 HP
21. Continuous HP at motor shaft per motor . . .	122 HP	125 HP
22. Continuous HP at wheel tread per motor wheel	120 HP	122 HP
23. Maximum axle load	11 075 kg	15 035 k
24. Coefficient of utilisation of adhesive weight . .	.43 (7-car train)	.43 (7-car tr
25. Adhesive weight at wheel rim per HP at continuous rating	63 kg/HP	78 kg/H
26. One hour tractive effort at wheel tread per motor	1 285 kg	1 310 kg
27. Continuous tractive effort at wheel tread per motor	835 kg	875 kg
28. Maximum tractive effort at wheel tread per motor	1 930 kg (Transition)	1 930 k
29. Variation in drawbar pull	Not applicable to multiple unit stoc	
30. Current supply	D. C.	D. C.
31. Number of traction motors.	2 per motor car	2 per motor 4 per meta
32. Type of motor	D. C. series Ventilated (BSS 173/1928)	D. C. ser Ventilate
33. Maximum voltage per armature.	650 V	700 V moto 800 V regene
34. Motor connections.	Series — parallel	2 pairs of m in parallel co across meta
35. Speed at one hour rating	35 km/h.	31 km/h.
36. Speed at continuous rating	39.5 km/h.	38.4 km/
37. Maximum test speed	96.7 km/h.	96.7 km/
38. Arrangement of motors	Axle hung	Axle hu
QUESTION 7.		
Publications in which vehicles are described	« Railway Gazette » 1.7.38	« Railway Ga Electric Tra Supplement

British Railways — Southern Region		British Railways — Eastern Region	
le unit electric notor cars	Electric locomotives	Tyneside stock	Liverpool st. — Shenfield Stock
280 HP	245 HP	222 HP	214 HP
250 HP	216 HP	216 HP	210 HP
enclosed motors	177 HP	159 HP	162 HP
enclosed motors	158 HP	154 HP	157 HP
3 868 kg	18 420 kg	12 300 kg	12 925 kg
—	104 kg/HP	80 kg/HP	81.5 kg/HP
1 769 kg	1 470 kg	1 284 kg	1 070 kg
—	842 kg	721 kg	650 kg
3 107 kg	3 390 kg	1 680 kg	2 242 kg
licable to multiple init stock	Not known	Not applicable to multiple unit stock	
D. C.	D. C.	D. C.	D. C.
per motor coach	6	2 per motor car	4 per car
. C. series	D. C. series	D. C. series	D. C. series
660 V	400 V	630 V	750 V
es — parallel	Two groups of 3 in series	Series — parallel	2 pairs in permanent series Series — parallel
3.5 km/h.	46 km/h.	44.9 km/h.	55.1 km/h.
—	57 km/h.	57.4 km/h.	68 km/h.
27 km/h.	120 km/h.	124 km/h.	124 km/h.
xle hung	Axle hung	Axle hung	Axle hung
way Gazette » 11.10.46 ern Transport » 7.9.46	« Railway Gazette » « Modern Transport »	« Railway Gazette » October 1939	« Railway Gazette » « The Engineer » October 1949

6. Principal characteristics of the vehicles considered (Continued).

QUESTION	Ceylon Governm[ent] Multiple unit Diesel Electric motor cars
1. Car builders	—
Electrical equipment	English Electric Co. Ltd.
2. Designation	« S. 1 » class
4. Axle arrangement	See drawings
5. Date in service	1947
6. Number in service 1949	12 cars
7. Total weight	—
8. Total adhesive weight	26 168 kg
8. Total weight of mechanical parts	—
10. Total weight of electrical equipment	—
11. Diameter of new motor wheels	86.3 cm
12. Diameter of non-motored wheels	86.3 cm
13. Type of axle bearing	Roller
14. Wheel balance	Statically
15. Type of brake	Vacuum
16. Brake leverage	—
17. Braking of non-motored axles	Yes
18. Number of brake blocks per wheel	2
19. One hour HP at motor shaft per motor	80 HP
20. One hour HP at wheel treads per motor wheel	—
21. Continuous HP at motor shaft per motor	62 HP
22. Continuous HP at wheel tread per motor wheel	—
23. Maximum axle load	10 500 kg
24. Coefficient of utilisation of adhesive weight	—
25. Adhesive weight at wheel rim per HP at continuous rating	—
26. One hour tractive effort at wheel tread per motor	—
27. Continuous tractive effort at wheel tread per motor	—
28. Maximum tractive effort at wheel tread per motor	—
29. Variation in drawbar pull	—
30. Current supply	D. C.
31. Number of traction motors	2 per motor bogie
32. Type of motor	—
33. Maximum voltage per armature	360 V
34. Motor connections	Series — parallel
35. Speed at one hour rating	—
36. Speed at continuous rating	—
37. Maximum test speed	96.4 km/h.
38. Arrangement of motors	Axle hung
QUESTION 7.	
Publications in which vehicles are described	« Railway Gazette »

ways	British Railways (Midland region)	Victorian Government Railways
iesel electric rail cars	Multiple unit electric motor cars	Multiple unit electric motor cars
—	Midland Region, British Railways	Victorian Government Railways
glish Electric Co. Ltd.	English Electric Co. Ltd.	General Electric Co. N. Y.
« T. 1 » class	—	« M » class
See drawings	—	See drawings
1938	1939	1919
23 cars	59	403
37 796 kg	42 600 kg	51 390 kg
—	42 600 kg	51 390 kg
—	30 000 kg	35 780 kg
—	12 600 kg	15 610 kg
86.3 cm	91.4 cm	106.8 cm
86.3 cm	None	None
Roller	Tapered roller	White metal
Statically	Statically	None
Vacuum	Self lapping E. P. Westinghouse	Automatic Westinghouse
—	4 : 1	9.92 : 1
Yes	—	—
2	2	2
112 HP	235 HP	146.6 HP
—	209 HP	140 HP
75 HP	184 HP	91 HP
—	164 HP	86 HP
10 500 kg	13 750 kg	13 270 kg
—	—	—
—	75 kg/HP	59.7 kg/HP
—	945 kg	1 000 kg
—	620 kg	454 kg
—	1 860 kg	1 540 kg
—	Not applicable to multiple unit trains	
D. C.	D. C.	D. C.
2 per car	4 per car	4 per car
—	D. C. series	D. C. series
360 V	580 V	750 V
Series — parallel	Series — parallel	2 pairs in permanent series Series — parallel
—	67.6 km/h.	38.6 km/h.
—	79.7 km/h.	50.6 km/h.
88.4 km/h.	124 km/h.	94.9 km/h.
Axle hung	Axle hung	Axle hung
« Railway Gazette »	« Railway Gazette »	—

The Pennsylvania Railroad.

Answers to Question **6** *under « A » general for electric locomotives.*

2. Method of designation by the railroad	B 1 Switching	D D 1 Passenger	D D 2 Freight	G G 1 Freight
1. Builders	P. R. R.	P. R. R.	P. R. R.	P. R. R. G. E. Co.
4. Arrangement of the axles — A.A.R. symbols	C	2 - B+B - 2	2 - B+B - 2	2 - C+C - 2
5. Date in service of the first vehicle of this type	1926	1910	1938	1935
6. Number of vehicles of the same type in service in 1949	28	2	1	44
7. Total weight in running order — kg.	12 000	150 000	206 000	211 000
8. Total adhesive weight — kg.	123 000	92 000	131 000	137 000
9. Total weight of mechanical parts — kg.	41 500	96 000	132 000	139 000
10. Total weight of electrical equipment — kg.	30 400	54 500	74 000	71 500
11. Diameter of new motor wheels — cm	157	183	157	145
12. Diameter of new non-motored wheels — cm	—	91.5	91.5	91.5
13. Type of axlebox bearing	Plain	Plain	Roller	Roller
14. Are wheels balanced statically and dynamically?	No	No	No	No
15. Type of brake	Air	Air	Air	Air
16. Brake leverage	6.1	7.8	9.4	9.0
17. Are there brakes on non-motored axles?	—	Yes	Yes	Yes
18. Number of brake blocks per wheel	1	1	2	2
19. The one hour horsepower at motor shafts	—	—	—	—
20. The one hour horsepower at wheel treads	735	—	—	—
21. Continuous horsepower at motor shafts	—	—	—	—
22. Continuous horsepower at wheel treads	570	1 580	5 000	7 620

Exhibit « A »

Sheet 1 of 7

L 6 eight	L 6 a Freight	O 1 A Passenger	O 1 C Passenger	P 5 Freight	P 5 a Freight	P 5 b Freight	R 1 Passenger
R. R.	LIMA.L.W. P. R. R.	P. R. R.	P. R. R.	P. R. R.	P. R. R. G.E. Co.	Baldwin	Baldwin
D - 1	1 - D - 1	2 - B - 2	2 - B - 2	2 - C - 2	2 - C - 2	2 - C - 2	2 - D - 2
932	1933	1930	1931	1931	1932	1932	1934
2	1	1	1	2	89	1	1
7 000	140 000	141 500	137 000	180 000	180 000	203 000	190 000
0 000	101 000	71 500	69 000	100 000	100 000	203 000	113 000
5 000	86 000	98 000	99 000	107 000	107 000	100 000	124 000
2 600	53 500	48 500	47 600	72 500	72 500	104 000	66 000
157	157	183	183	183	183	183	157
91.5	91.5	91.5	91.5	91.5	91.5	91.5	91.5
oller	Roller	Roller	Roller	Roller	Roller	Roller	Roller
No	No	No	No	No	No	No	No
Air	Air	Air	Air	Air	Air	Air	Air
7.2	1.2	7.15	7.15	9.7	9.7	8.13	8.25
No	No	Yes	Yes	Yes	Yes	—	Yes
2	2	2	2	2	2	2	2
—	—	—	—	—	—	—	—
—	—	—	—	—	—		—
—	—	—	—	—	3 840	—	—
500	2 500	2 500	2 500	3 750	3 750	5 350	5 000

The Pennsylvania Railroad.

Answers to Question 6 *under « A » general for electric locomotives.* (Continued).

2. Method of designation by the railroad	B 1 Switching	D D 1 Passenger	D D 2 Freight	G G 1 Freight	G G 1 Passeng
23. The maximum axle loads (at rail) — kg	23 800	23 300	32 500	22 900	23 00
24. Coefficient of utilisation of adhesive weight	.25	.25	.25	.25	.23
25. Adhesive weight at the wheel rim per horse power at the continuous rating — kg/HP	126	59	26	30	30
26. One hour traction effort at the wheel treads — kg.	—	—	—	—	—
27. Continuous traction effort at the wheel treads — kg.	6 200	4 700	17 600	8 800	7 90
28. Maximum traction effort at the wheel treads — kg.	18 000	23 300	32 800	34 400	32 50
29. Variation in maximum drawbar pull during the transition changes in the connections of the traction motors	—			—	—
30. Type of current supplied to the traction motors	A. C.	D. C.	A. C.	A. C.	A. C
31. Number of traction motors	3	2	8	12	12
32. Type of traction motors	W.E. 137-B A.A.C. 100	W.E. 315-A	W.E. 428-A	W.E. 427 G.E. 627	W.E. 4 G.E. 6
33. Maximum voltage at the motor brushes per armature	235	650	340	340	340
34. The different electrical connections of the traction motors	Parallel only	4 permanently in series	4 permanently in series	4 permanently in series	4 perman in seri
35 Speed of the motor vehicle at the one hour rating — km/h.	—	—	—	—	—
36. Speed of the motor vehicle at a continuous rating — Km/h.	25.5	93	79	145	160
37. Rated maximum test speed of the motor vehicle — Km/h.	10	129	112	145	160
38. Arrangement of motors on the vehicle	Axle hung	Frame mounted	Frame mounted	Frame mounted	Fram mount
Gear ratio(*)	16 : 87	(Jack shaft)	21 : 83	22 : 79	24 :

(*) This is in answer to Question No. 34 under « Drives ».

Exhibit « A »

Sheet 1 of 7

L 6 reight	L 6 a Freight	O 1 A Passenger	O 1 C Passenger	P 5 Freight	P 5 a Freight	P 5 b Freight	R 1 Passenger
5 200	26 500	36 200	34 400	33 800	35 200	35 800	28 200
.25	.25	.21	.22	.25	.26	.18	.25
40	40	28	27	27	27	38	22
—	—	—	—	—	—	—	—
1 500	11 500	6 800	6 800	13 100	13 100	18 800	8 600
5 200	25 300	15 400	15 400	25 200	26 200	36 600	28 800
not determined		—	—	—	—	—	—
. C.	A. C.	A. C.	A. C.	A. C.	A. C.	A. C.	A. C.
4	4	4	4	6	6	10	8
W.E. 25-B	W.E. 425-B	G.E. 619-A	W.E. 425-A G.E. 625-A	W.E. 425-A G.E. 625-A	W.E. 425-A G.E. 625-A	W.E. 425-A G.E. 625-A	W.E. 428
275	275	225	275	275	275	275	340
per- nently series	2 permanently in series	2 permanently in series	2 permanently in series	3 permanently in series	3 permanently in series	5 permanently in series	4 permanently in series
—	—	—	—	—	—	—	—
60	60	101	101	79	79	79	160
87	87	145	145	112	112	112	160
xle ung	Axle hung	Frame mounted	Frame mounted	Frame mounted	Frame mounted	Frame mounted	Frame mouned
: 86 : 98	20 : 86	36 : 103	31 : 91	25 : 97	25 : 97	25 : 97 17 : 50 (Truck)	27 : 74

The Pennsylvania Railroad.

Answers to Question **6** *under « A General » for Diesel road locomotives.*

2. Method of designation by the railroad	AP-3 2-«A» units 1-«B» unit	BP-3 2-«A» units 1-«B» unit	EP-3 2-«A» un 1-«B» u
1. Builders	A.L. Co.	Baldwin	E.M.D
4. Arrangement of the axles — A.A.R. symbols	3 (AIA-AIA)	3 (AIA-AIA)	3 (AIA-A
5. Date in service of the first vehicle of this type	1947	1948	1945
6. Number of vehicles of same type in service in 1949	5	9	14 + (15 uni
7. Total weight in running order — kg	427 000	526 000	434 00
8. Total adhesive weight — kg	284 000	350 000	292 00
9. Total weight of mechanical parts — kg	—	—	—
10. Total weight of electrical or Diesel electrical equipment	—	—	—
11. Diameter of new motor wheels — cm	40	42	36
12. Diameter of new non-motored wheels — cm	40	42	36
13. Type of axle box bearing	Roller	Roller	Rolle
14. Are wheels balanced statically and dynamically?	No	No	No
15. Type of brake	Air	Air	Air
16. Brake leverage	7.3	8.45	7.3
17. Are there brakes on non-motored axles?	Yes	Yes	Yes
18. Number of brake blocks per wheel	2	2	2
19. The one hour horse power at motor shafts	—	—	—
20. The one hour horse power at wheel treads	—	—	—
21. Continuous horse power at motor shafts	—	—	—
22. Continuous horse power at wheel treads, approx.	5 000	5 000	5 00
23. The maximum axle loads (at rail — kg)	24 100	30 000	24 80
24. Coefficient of utilisation of adhesive weight	.25	.25	.25
25. Adhesive weight at the wheel rim per horse power at the continuous rating — kg./HP	57	70	58
26. One hour tractive effort at the wheel treads — kg	—	—	—
27. Continuous tractive effort at the wheel treads — kg	37 000	36 000	25 70
28. Maximum tractive effort at the wheel treads kg (25 % adhes.)	71 000	88 000	73 00
29. Variation in maximum drawbar pull during the transition changes in the connections of the traction motors	—	—	—
30. Type of current supplied to the traction motors	D. C.	D. C.	D. C
31. Number of traction motors	4	4	4
32. Type of traction motors	G.E. 566	W.E. 471-A	E.M.D.
33. Maximum voltage at the motor brushes per armature	600	300	600
34. The different electrical connections of the traction motors	Series, parallel combinations	Series, parallel combinations	Serie parall combina
35. Speed of the motor vehicle at the one hour rating, — km/h.	—	—	—
36. Speed of the motor vehicle at a continuous rating — km/h.	37	32	55
37. Rated maximum test speed of the motor vehicle — km/h.	160	160	155
38. Arrangement of motors on the vehicle	Axle hung	Axle hung	Axle h
Gear ratio (*)	23 : 60	22 : 57	22 :

Note. — Road Diesel locomotives as designated, being made up of lead and booster units with m to changes with respect to the number of units of same class used per locomotive depending upon opera

(*) This is in answer to Question No. 34, under « Drives ».

Exhibit A
Sheet 2 of 7

FP-3 «A» units «B» unit	BP-1	AF-4 2-«A» units 2-«B» units	BF-4 2-«A» units 2-«B» units	EF-3 2-«A» units 1-«B» unit	EF-4 2-«A» units 2-«B» units	FF-3 2-«A» units 1-«B» unit
airbanks Morse	Baldwin	A.L. Co.	Baldwin	E.M.D.	E.M.D.	Fairbanks Morse
AIA-AIA)	2-D+D-2+ 2-D+D-2	4 (B-B)	4 (B-B)	3 (B-B)	4 (B-B)	3 (AIA-AIA)
1948	1947	1948	1949	1948	1947	1947
4	12	2	13	18	18 + (28 «A» units 1 «B» unit)	8 + (12-«A» units)
456 000	545 000	440 000	480 000	326 000	426 000	487 000
318 000	376 000	440 000	480 000	326 000	426 000	338 000
—	—	—	—	—	—	—
—	—	—	—	—	—	—
42	42	40	42	40	40	42
42	42	—	—	—	—	—
Roller	Roller	Roller	Roller	Roller	Roller	Roller
No	No	No	No	No	No	No
Air	Air	Air	Air	Air	Air	Air
7.45	7.1	5.6	5.95	5.65	5.65	7.45 (using-B relay)
Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	2	2	2	2	2	2
—	—	—	—	—	—	—
—	—	—	—	—	—	—
—	—	—	—	—	—	—
5 000	5 000	5 000	5 000	3 750	5 000	5 000
26 700	26 700	28 800	31 200	27 400	27 400	28 600
.25	.25	.25	.25	.25	.25	.25
64	75	88	96	87	85	68
—	-	—	—	—	—	—
37 600	48 100	78 000	79 000	58 300	59 500	56 500
79 500	93 500	110 000	120 000	81 000	106 000	84 500
—	—	—	—	—	—	—
D. C.	D. C.	D. C.	D. C.	D. C.	D. C.	D. C.
4	16	4	4	4	4	4
E GT-567	W.E. 370-F	G.E. 752	W.E. 370-F	E.M.D. D 7 E	E.M.D. D 17 B	G.E. 746
600	300	600	350	600	600	600
Series, parallel mbinations	Series, parallel combinations	Series, parallel combinations	Series, parallel combinations	Series, parallel combinations	Series, parallel combinations	Series, parallel combinations
—	—	—	—	—	—	—
35	29	17	17	17	23	25
160	160	105	105	80	105	111
xle hung	Axle hung	Axle hung	Axle hung	Axle hung	Axle hung	Axle hung
23 : 64	22 : 57	18 : 74	15 : 63	12 : 65	15 : 62	17 : 70

nilarity as to details, including tractive force, are used in multiple as indicated. They will at times be subjected
nditions.

The Pennsylvania Railroad.

Answers to Question **6** *under « A. General » for Diesel-electric shifting locomotives.*

2. Method of designation by the railroad	G.S.-4	A.S.-6	B.S.-6	B.S.-6 a	E.S No.
1. Builders	General electric	A.L. Co.	Baldwin	Baldwin	E.M
4. Arrangement of the axles — A.A.R. symbols	B-B	B-B	B-B	B-B	B-
5. Date in service of the first vehicle of this type	1947	1947	1942	1948	19
6. Number of vehicles of same type in service in 1949 (as of 7-1-49)	42	17	12	99	1
7. Total weight in running order — Kg.	40 500	91 000	90 000	90 000	95
8. Total adhesive weight — Kg.	»	»	»	»	»
9. Total weight of mechanical parts — Kg.	—	—	—	—	—
10. Total weight of electrical or Diesel electrical equipment	—	—	—	—	—
11. Diameter of new motor wheels — cm.	84	102	102	120	10
12. Diameter of new non-motored wheels — cm.	—	—	—	—	—
13. Type of axlebox bearing	Plain	Plain	Plain	Plain	Pla
14. Are wheels balanced statically and dynamically?	No	No	No	No	N
15. Type of brake	Air	Air	Air	Air	A
16. Brake leverage	5.2	5.3	5.4	5.4	5.
17. Are there brakes on non-motored axles?	—	—	—	—	—
18. Number of brake blocks per wheel	2	2	2	2	2
19. The one hour horse power at motor shafts	—	—	—	—	Not
20. The one hour horse power at wheel treads	—	—	—	—	—
21. Continuous horse power at motor shafts	—	—	—	—	—
22. Continuous horse power at wheel treads	250	490	506	481	48
23. The maximum axle loads (at rail — Kg.)	10 000	23 300	23 300	22 500	23
24. Coefficient of utilisation of adhesive weight	100 %	100 %	100 %	100 %	100
25. Adhesive weight at the wheel rim per horse power at the continuous rating — Kg./HP	163	188	180	187	19
26. One hour tractive effort at the wheel treads — Kg.	—	—	—	—	—
27. Continuous tractive effort at the wheel treads — Kg.	5950	13 500	13 500	15 600	9
28. Maximum tractive effort at the wheel treads — Kg. (25 % adhesion)	10 200	22 800	22 600	22 400	23
29. Variation in maximum drawbar pull during the transition changes in the connections of the traction motors	—	—	—	—	—
30. Type of current supplied to the traction motors	D. C.	D. C.	D. C.	D. C.	D.
31. Number of traction motors	4	4	4	4	4
32. Type of traction motors	G. E. 733	G. E. 791-D 3	W. E. 362-B	W. E. 362-D	W. 287-E
33. Maximum voltage at the motor brushes per armature	250	350	350	350	60
34. The different electrical connections of the traction motors	—	—	—	—	—
35. Speed of the motor vehicle at the one hour rating — Km/h.	—	—	—	—	—
36. Speed of the motor vehicle at a continuous rating — Km/h.	11.5	10	10.5	8.5	14.
37. Rated maximum test speed of the motor vehicle — Km/h.	56	96	96	96	64
38. Arrangements of the motors on the vehicle	Axle hung	Axle hung	Axle hung	Axle hung	Axle
Gear ratio (*)	1: 11 1/4	16 : 75	16 : 76	14 : 68	16 :

(*) This is in answer to Question No. 34, under « Drives ».

Exhibit « A »

Sheet 3 of 7

S.-6	A.S.-10	B.S.-10	B.S.-10A	B.S.- 10 M.U.	E.S.-10	F.S.-10	F.S.-20	A.S.-10 S	B.S.-10 A.S.
M.D.	A.L. Co.	Baldwin	Baldwin	Baldwin	E.M.D.	Fair-banks-M	Fair-banks-M	A.L. Co.	Baldwin
3-B	B-B	B-B	B-B	B-B	B-B	B-B	B-B	B-B	B-B
942	1948	1943	1948	1948	1941	1948	1949	1948	1949
52	22	8	86	6	32	35	12	1	2
9 000	106 000	110 000	105 000	105 000	114 000	112 000	117 000	114 000	116 000
»	»	»	»	»	»	»	»	»	»
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
02	102	102	102	102	102	102	107	102	107
—	—	—	—	—	—	—	—	—	—
ain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain	Plain
No	No	No	No	No	No	No	No	No	No
Air	Air	Air	Air	Air	Air	Air	Air	Air	Air
.4	5.3	5.4	5.4	5.4	5.4	5.35	5.35	5.3	5.4
—	—	—	—	—	—	—	—	—	—
2	2	2	2	2	2	2	2	2	2
used	—	—	—	—	Not used	—	—	—	—
—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
70	725	753	816	816	800	807	1 678	725	821
200	26 800	28 000	26 000	26 000	28 300	28 300	29 000	28 300	28 300
) %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
90	148	146	128	129	143	138	234	161	135
—	—	—	—	—	—	—	—	—	—
800	15 600	15 600	15 600	15 600	13 800	15 600	19 700	15 600	14 900
200	26 800	27 500	26 200	26 200	28 500	27 200	29 100	28 600	27 600
ot determined		—	—	—	—	—	—	—	—
C.	D. C.	D. C.	D. C.	D. C.	D. C.	D. C.	D. C.	D. C.	D. C.
4	4	4	4	4	4	4	4	4	4
I.D.	G. E.	W. E.	W. E.	W. E.	E.M.D.	W. E.	W. E.	W. E.	W. E.
173	731-D	362-D	362-D	362-D	D 17 B	362-D	370-F	731-D	362-D
00	350	350	350	350	600	350	380	350	350
eries and series — parallel			—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—
2	12.9	13.3	14.5	14.5	16	14.3	23.5	13	15
2	96	96	96	96	96	96	104	96	96
hung	Axle hung	Axle hung	Axle hung	Axle hung	Axle hung	Axle hung	Axle hung	Axle hung	Axle hung
62	16 : 75	14 : 68	14 : 68	14 : 68	15 : 62	14 : 68	15 : 62	16 : 75	14 : 68

The Pennsylvania Railroad.

Answers to Question **6** *under « A » General for electric motor coaches (M-U cars).*

2. Method of designation by the railroad	MP 54 E 1	MP 54 E 2	MP 54 E
1. Builders	A.C. + F., P.R.R., pressed steel car, S.T.D. Steel Car Co.		P.R.R. P.S.C. C A.C. + S.S.C.
4. Arrangement of the axles	—	—	—
5. Date in service of the first vehicle of this type	1914	1925	1933
6. Number of vehicles of the same type in service in 1949	117	200	38
7. Total weight in running order — kg.	54 200	59 600	58 00
8. Total adhesive weight — kg.	32 400	34 600	34 60
9. Total weight of mechanical parts — kg.	—	—	—
10. Total weight of electrical equipment — kg.	—	—	—
11. Diameter of new motor wheels — cm	91.5	91.5	91.5
12. Diameter of new non-motored wheels — cm	91.5	91.5	91.5
13. Type of axlebox bearing	Plain	Some-Plain Some-roller	Trailer-p motor-r
14. Are wheels balanced statically and dynamically?	No	No	No
15. Type of brake	Air	Air	Air
16. Brake leverage	11.3	12.4	12.1
17. Are there brakes on non-motored axles?	Yes	Yes	Yes
18. Number of brake blocks per wheel	2	2	2
19. The one hour horse power at motor shafts, per motor.	221	252	—
20. The one hour horse power at wheel treads, per motor.	205	229	—
20. Continuous horse power at motor shafts, per motor.	196	206	380
22. Continuous horse power at wheel treads, per motor.	185	193	370
23. The maximum axle loads (at rail — kg.)	16 200	17 000	17 00
24. Coefficient of utilisation of adhesive weight	.25	.25	.25
25. Adhesive weight at the wheel rim per horse power at the continuous rating — kg./HP	87	89	47
26. One hour tractive effort at the wheel treads — kg. per motor.	940	1 110	—
27. Continuous tractive effort at the wheel treads — kg. per motor.	760	825	1 3
28. Maximum tractive effort at the wheel treads — kg. per motor.	8 100	8 650	8 6
29. Variation in maximum drawbar pull during the transition changes in the connections of the traction motors.	—	—	—
30. Type of current supplied to the traction motors.	A. C.	A. C.	A.
31. Number of traction motors	2	2	2
32. Type of traction motors	412 a Doubly-fed	412 d Doubly-fed	426 or Seri
33. Maximum voltage at the motor brushes per armature.	—	—	—
34. The different electrical connections at the traction motors	—	—	—
35. Speed of the motor vehicle at the one hour rating, km.h.	61	—	—
36. Speed of the motor vehicle at a continuous rating, km.h.	68	—	—
37. Rated maximum test speed of the motor vehicle, km.h.	104	104	12
38. Arrangement of motors on the vehicle	Axle hung	Axle hung	Axle
Gear ratio (*)	24 : 55	24 : 55	22 :

(*) This is in answer to Question No. 34 under « Drives ».

Exhibit « A »

sheet 4 of 7

E 1	MPB 546 E 2	MPB 546 E 3	MBM 62 E 1	MBM 62 E 2	MB 62 E 1	MB 62 E 2
F.	A.C.+ F.	P.R.R.	P.R.R.	P.R.R.	P.R.R.	P.R.R.
our wheel trucks		—	—	—	—	—
	1928	1933	1928	1928	1926	1926
	2	8	2	2	2	5
00	53 300	57 000	55 000	55 000	54 600	54 600
00	33 400	34 000	32 000	32 000	32 600	32 600
	—	—	—	—	—	—
	—	—	—	—	—	—
5	91.5	91.5	91.5	91.5	91.5	91.5
5	91.5	91.5	91.5	91.5	91.5	91.5
n	Plain	Trailer-plain motor-roller	Plain	Plain	Plain	Plain
	No	No	No	No	No	No
	Air	Air	Air	Air	Air	Air
	11.2	11.9	11.5	11.5	11.4	11.4
	Yes	Yes	Yes	Yes	Yes	Yes
	2	2	2	2	2	2
	252	—	221	252	221	252
	229	—	205	229	205	229
	206	380	196	206	196	206
	193	370	185	193	185	193
0	16 800	17 000	16 000	16 000	16 600	16 600
	.25	25	.25	.25	.25	.25
	86	46	87	84	88	85
	1 110	—	940	1 110	940	1 110
	825	1 360	760	825	760	825
0	8 300	8 500	8 090	8 090	8 090	8 090
ot determined		—	—	—	—	—
.	A. C.	A. C.	A. C.	A. C.	A. C.	A. C.
	2	2	2	2	2	2
a	412 d	426 or 626	412 a	412 d	412 a	412 d
-fed	Doubly-fed	Series	Doubly-fed	Doubly-fed	Doubly-fed	Doubly-fed
ot determined		—	—	—	—	—
manently in series		—	—	—	—	—
	—	—	61	—	61	—
	—	—	68	—	68	—
	104	121	104	104	104	104
ung	Axle hung	Axle hung	Axle hung	Axle hung	Axle hung	Axle hung
55	24 : 55	22 : 57	24 : 55	24 : 55	24 : 55	24 : 55

The Pennsylvania Railroad.

Answers to Question **6** *under « A » General for rail motor cars.*

2. Method of designation by the railroad	O.E.W. 330 a	O.E.G.
1. Builder	Pullman	Pullm
4. Arrangement of the axles		
5. Date in service of the first vehicle of this type	1941	1942
6. Number of vehicles of the same type in service in 1949	1	10
7. Total weight in running order — kg.	65 000	57 7
8. Total adhesive weight — kg.	41 200	35 5
9. Total weight of mechanical parts — kg.	—	—
10. Total weight of electrical equipment — kg.	—	—
11. Diameter of new motor wheels — cm	91.5	91.5
12. Diameter of new non-motored wheels — cm	91.5	91.5
13. Type of axlebox bearing	Roller	Rolle
14. Are wheels balanced statically and dynamically?	No	No
15. Type of brake	Air	Air
16. Brake leverage	10.7	9.6
17. Are the brakes on the non-motored axles?	Yes	Yes
18. Number of brake blocks per wheel	2	2
19. The one hour horse power at the motor shafts		
20. The one hour horse power at the wheel treads	212	235
21. Continuous horse power at the motor shafts	—	—
22. Continuous horse power at the wheel treads	249	246
23. The maximum axle loads (at rail — kg.)	20 500	17 6
24. Coefficient of utilisation of adhesive weight	.13	.13
25. Adhesive weight at the wheel rim per horse power at the continuous rating — kg./HP	165	146
26. One hour tractive effort at the wheel tread — kg.	3 160	2 2
27. Continuous tractive effort at the wheel tread — kg.	1 550	1 7
28. Maximum tractive effort at the wheel tread — kg.	5 400	4 8
29. Variation in maximum drawbar pull during the transition changes in the connections of the traction motors	—	—
30. Type of current supplied to the traction motors	D. C.	D.
31. Number of traction motors	2	2
32. Type of traction motors	W.E. 569-c-4	G.E. 2
33. Maximum voltage at the motor brushes per armature	700	70
34. The different electrical connections of the traction motors	One motor per power plant	One m per powe
35. Speed of the motor vehicle at the one hour rating — m.p.h.	11.5	18
36. Speed of the motor vehicle at the continuous rating — m.p.h.	27.5	25
37. Rated maximum test speed of the motor vehicle — m.p.h.	60	60
38. Arrangement of motors on the vehicle	Axle hung	Axle h
Gear ratio(*)	20 : 59	18 :

(*) This is in answer to Question No. 34 under « Drives ».

Exhibit « A »
Sheet 5 of 7

E.G. 350 b	O.E.G. 400	O.E.G. 415	O.E.W.G. 350
Pullman heel trucks	Pullman	Brill	Brill
1942	1942	1942	1942
2	1	5	2
57 700	66 600	64 000	59 000
35 500	44 000	41 000	37 800
—	—	—	—
—	—	—	—
91.5	91.5	91.5	91.5
91.5	91.5	91.5	91.5
Roller	Roller	Roller	Roller
No	No	No	No
Air	Air	Air	Air
9.6	11.0	10.5	9.8
Yes	Yes	Yes	Yes
2	2	2	2
ed			
235	249	249	230
—	—	—	—
246	299	299	240
17 600	21 800	20 200	18 800
.13	.18	.19	.16
—	—	—	—
146	147	137	157
2 260	3 300	3 300	2 920
1 700	2 330	2 330	1 550
5 400	7 800	7 800	6 000
erminded			
D. C.	D. C.	D. C.	D. C.
2	2	2	2
:. 292-c-51	G.E. 297	G.E. 110-A	W.E. 569-c-4
700	700	700	700
ne motor ower plant	Series and parallel	Series and parallel	One motor per power plant
18	13	13	12.5
25	22	22	26.5
60	60	60	60
xle hung	Axle hung	Axle hung	Axle hung
8 : 53	20 : 56	20 : 56	20 : 59

MODEL NUMBER and HP (1)	Unit (2)	DIMENSIONS: Length overall inside kauckles (3)	Width maximum over side sills (4)	Height max. above rails (5)	Wheel base between truck center (6)	WEIGHT & CAPACITIES (a: Weight: Total (lbs.) (7)	On drivers (lbs.) (8)	Starti tractive: 25 % adhn. (lbs.) (9)
ROAD FRE								
Alco-G. E. (American Locomotive Co., and General Electric Co., Shenectady, N. Y. (Latest data not available at								
Baldwin Locomotive Works, Eddystone, Pennsylvania.								
DR-4-415 1 500 HP	A B	54′-8″ 53′-2″	9′-10″ (1) 10′- 6″	15′-0″	28′-2″	250 000	250 000	62 500
Electro-Motive Division, General Motors Corporation, La Grange, Illinois.								
F-7 1 500 HP	A B	50′-8″ 50′-0″	9′-10″ (1) 10′- 8″	15′-0″	30′-0″	230 000	230 000	57 500
Fairbanks, Morse & Co., Chicago, Illinois.								
ALT 200.3 2 000 HP (1)	A - B	64′-10″	10′-0″	15′-7″	36′-5″	344 000	240 000	60 000
ALT 100.3 2 000 HP (1)	A - B	64′-10″	10′-0″	15′-7″	36′-5″	324 000	220 000	55 000
C.F.-16-4 1 600 HP	A - B	56′-6″	10′-0″	15′-0″	34′	240 000	240 000	60 000
C.F.-20-4 2 000 HP	A - B	10′-0″	15′-0″	15′-0″	34′	246 000	246 000	61 500
C.F.-24-4 2 400 HP	A - B	56′-6″	10′-0″	15′-0″	34′	252 000	252 000	63 000
C.P.-16-4 1 600 HP	A - B	56′-6″	10′-0″	15′-0″	34′	250 000	250 000	62 500
ROAD PASSE								
Alco-G. E. (American Locomotive Co., and General Electric Co., Schenectady, N. Y.) (Latest data not available a								
Baldwin Locomotive Works, Eddystone, Pennsylvania.								
DR-6-4-20 2 000 HP	A B	80′-0″ 78′-2 1/2″	9′-10″ (1) 10′-6″	14′-9 3/8″	46′-3 1/2″	375 000	250 000	62 500
Electro-Motive Division, General Motors Corporation, La Grange, Illinois.								
E-8 2 250 HP	A B	70′-3″ 70′-0″	9′-10″ (1) 10′- 8″	14′-10 1/2″	43′-0″	316 500 308 300	210 750 207 500	52 700 51 800

ENGINE														
Type	Make	Cycle	Cycle per engine	Bore and Stke (in.)	Fuel system		Comp. ratio	Firing pressure (max.)	M.E.P. (mean effective pressure)	Charger		Continuous ratings per engine		HP available for traction
					Type	Make				Type	Make	RPM	HP	
(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
OMOTIVES														
-time.)														
Str.	Own	4	8	12 3/4×15	S.I.	Bosch or Bendix	13.45:1	1 050	130	Turbo	Elliot	625	1 625	1 500
V	Own	2	16	8 1/2×10	U	Own	16.8:1	1 050	92	R	Own	800	—	1 500
O.P.	Own	2	10	8 1/8×10 (1)	S.I.	Own	16.1:1	1 150	93	Blower	Own	850	2 200	2 000
O.P.	Own	2	10	8 1/8×10 (1)	S.I.	Own	16.1:1	1 150	93	Blower	Own	850	2 200	2 000
O.P.	Own	2	8	8 1/8×10 (1)	S.I.	Own	16.1:1	1 150	93	Blower	Own	850	1 804	1 600
O.P.	Own	2	10	8 1/8×10 (1)	S.I.	Own	16.1:1	1 150	93	Blower	Own	850	2 223	2 000
O.P.	Own	2	12	8 1/8×10 (1)	S.I.	Own	16.1:1	1 150	93	Blower	Own	850	2 623	2 400
O.P.	Own	2	8	8 1/8×10 (1)	S.I.	Own	16.1:1	1 150	93	Blower	Own	850	1 804	1 600
OMOTIVES														
-time.)														
Str.	Own	4	6	12 3/4×15 1/2	S.I.	Bosch or Bendix	13.451	1 050	120	Turbo	Elliot	625	1 125	2 000
V	Own	2	12	8 1/2×10	U	Own	16.8:1	1 050	92	R	Own	800	—	2 250

MODEL NUMBER a HP (1)	Unit (2)	DIMENSIONS Length overall inside kauckles (3)	Width maximum over side sills (4)	Height max. above rails (5)	Wheel base between truck center (6)	WEIGHT & CAPACITIES (ap Weight Total (lbs.) (7)	On drivers (lbs.) (8)	Startin tractive e 25 % adhn. (lbs.) (9)
Fairbanks, Morse & Co., Chicago, Illinois. (See also models Alt. 100.3 (2 000 HP) — and CP 16-4 (1 600 HP) un								
CP 16-5	A - B	56′-6″	10′-0″	15′-0″	31′	272 000	222 000	55 500
CP 90-5	A - B	56′-6″	10′-0″	15′-0″	31′	282 000	230 000	57 500
CP.-24-5	A - B	56′-6″	10′-0″	15′-0″	31′	286 000	234 000	58 500
						COMBINATION ROAD-SWITC		
Alco-G. E., Schenectady, N. Y. (Latest data not available at press time.)								
Baldwin Locomotive Works, Eddystone, Pennsylvania.								
DRS-4-4-15 1 500 HP	S	58′-0″	9′-10″	14′-0″	32′-3″	240 000	240 000	60 000
1 500 HP		(with boiler & water applied)				254 000	254 000	63 500
DRS-6-4-15 1 500 HP	S	58′-0″	9′-10″	14′-0″	32′-3″	256 000	177 000	44 250
		(with boiler & water applied)				270 000	186 500	46 625
DRS-6-6-15 1 500 HP	S	58′-0″	9′-10″	14′-1″	32′-3″	325 000	325 000	81 250
(Transfer)			10′-2″ (2)					
		(with boiler & water applied)				329 300	329 300	82 325
DT-6-6-20 2 000 HP	S	74′-0″	9′-10″	15′-4 1/4″	41′-0″	354 000	354 000	88 500
(Transfer)			10′-2″ (2)					
DRS-4-4-10 1 000 HP	S	58′-0″	9′-10″	14′-0″	32′-0″	224 000	224 000	56 000
		(with boiler & water applied)				235 000	235 000	58 750

Abbreviations and notes :

The bracketed numbers and abbreviations used in the tabulation refer to the following:
Bracketed numbers within tabulation, such as « (3) » refer to the following explanations:

Col. 1 : (1)—no longer in production ,(2)—not r mended for other than freight service. Howev be equipped with train heating equipment fo speed terminal and passenger service.
Col. 2 : S—single unit.
Col. 3 : ∅—date not available.

ENGINE														
Type	Make	Cycle	Cycle per engine	Bore and Stke (in.)	Fuel system		Comp. ratio	Firing pressure (max.)	M.E.P. (mean effective pressure)	Charger		Continuous ratings per engine		HP available for traction
					Type	Make				Type	Make	RPM	HP	
(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)
Freight Locomotives.)														
O.P.	Own	2	8	8 1/8×10 (1)	S.I.	Own	16.1:1	1 150	93	Blower	Own	850	1 804	1 600
O.P.	Own	2	10	8 1/8×10 (1)	S.I.	Own	16.1:1	1 150	93	Blower	Own	850	2 223	2 000
O.P.	Own	2	12	8 1/8×10 (1)	S.I.	Own	16.1:1	1 150	83	Blower	Own	850	2 623	2 400
NSFER) LOCOMOTIVES														
Str.	Own	4	8	12 3/4×15 1/2	S.I.	Bosch or Bendix	13.45:1	1 050	130	Turbo	Elliot	625	1 625	1 500
Str.	Own	4	8	12 3/4×15 1/2	S.I.	Bosch or Bendix	13.45:1	1 050	130	Turbo	Elliot	625	1 625	1 500
Str.	Own	4	8	12 3/4×15 1/2	S.I.	Bosch or Bendix	13.45:1	1 050	130	Turbo	Elliot	625	1 625	1 500
Str.	Own	4	8	12 3/4×15 1/2	S.I.	Bosch or Bendix	13.45:1	1 050	130	Turbo	Elliot	625	1 625	1 500
Str.	Own	4	8	12 3/4×15 1/2	S.I.	Bosch or Bendix	13.45:1	1 050	130	Turbo	Elliot	625	1 625	1 500
Str.	Own	4	8	12 3/4×15 1/2	S.I.	Bosch or Bendix	13.45:1	1 050	130	Turbo	Elliot	625	1 625	1 500
Str.	Own	4	6	12 3/4×15 1/2	S.I.	Bosch or Bendix	13.45:1	1 050	120	Turbo	Elliot	625	2 250	2 000
Str.	Own	4	6	12 3/4×15 1/2	S.I.	Bosch or Bendix	13.45:1	1 050	120	Turbo	Elliot	625	1 125	1 000
Str.	Own	4	6	12 3/4×15 1/2	S.I.	Bosch or Bendix	13.45:1	1 050	120	Turbo	Elliot	625	1 125	1 000

: (1)—width over handrails; (2)—width over
: cylinder.
2 : Str—straight; O.P.—opposed piston; V—
al, in line single acting.
: (1) 10-in. stroke for each of two pistons.

Col. 17 : St—solid injection: U—unit injection.
Col. 22 : R—Roots blower; S—supercharger; TS—turbo supercharger.
Col. 23: SC—Schwitzer-Cumming; BW—Borg-Warner; B—Buchi; E.B.—Elliot-Buchi.

SPECIFICATIONS OF

ELECTRICAL EQUIPMENT							TRUCKS							
Generators				Traction mtr					Wheels				Journ'l	
Main generator		Auxiliary generator		Total No. per unit	Type	Make	Type	Wheel base	Number driving (pairs)	Number idling (pairs)	Diam.	Min. curve radius	Type	Make
Type	Make	Type	Make											
(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)	(39)	(40)	(41)
ROAD FREI														
Alco-G. E. (American Locomotive Co., and General Electric														
Baldwin Locomotive Works, Eddystone, Pennsylvania.														
471	W	Y.G. 42 B	W	4	370	W	S.B.	9′-10″	4	None	42″	21°	R.B.	*
Electro-Motive Division, General Motors Corporation, La Grange, Illinois.														
Comb. AC-DC (1)	Own	D.C. Shunt	D.	4	D.C. Series	Own	(1)	9′-0″	4	None	40″	250°	R.B.	H.
Fairbanks, Morse & Co., Chicago, Illinois														
567	G.E.	27	G.E.	4	746	G.E.	S.B. (2)	15′-0″	4	2	42″	275°	R.B.	T.
567	G.E.	27	G.E.	4	746	G.E.	S.B. (2)	15′-5″	4	2	40″	275°	R.B.	T.
497	W.	Y.G. 54-B	W.	4	370	W.	S.B. (3)	9′-4″	4	None	42″	273°	R.B.	T.
498	W.	Y.G. 54-A	W.	4	370	W.	S.B. (3)	9′-4″	4	None	42″	273°	R.B.	T.
498	W.	Y.G. 54-A	W.	4	370	W.	S.B. (3)	9′-4″	4	None	42″	273°	R.B.	T.
497	W.	Y.G. 54-B	W.	4	370	W.	S.B. (3)	9′-4″	4	None	42″	273°	R.B.	T.

:CTRIC LOCOMOTIVES

Exhibit « A »
Sheet 6 of 7

	SPEED			AUXILIARIES								SUPPLIES				
				Starter		Air compressor			Traction motor blowers							
ar :os	Cont. trac-tive effort (lbs.)	Cont. rat-ing MPH	Max. speed MPH	Type	Make	Type	Make	Capa-city (C.F. M.)	T.	M.	Air brake sched.	Lub. oil cap. (gals)	Fuel oil cap. (gals)	Eng. cool-ing water cap. (gals)	Htg. boiler water cap. (gals)	Sand cap. (cu. ft)
3)	(44)	(45)	(46)	(47)	(48)	(49)	(50)	(51)	(52)	(53)	(54)	(55)	(56)	(57)	(58)	(59)
LOCOMOTIVES																
Schenectady, N. Y. (Latest data not available at press-time.)																
:15	42 800	10.5	65	Elec.	Gould	3-CD	W A B	262	Mech.	S.	24-R L	200	1 200	300	None	16
:17	37 200	12.2	75	Bty.	or	or	or		driver		D.B.					
:19	32 200	14.0	82		Exide	W X O	G D									
:20	30 000	15.0	87.5													
:21	28 100	16.0	93.5													
:12	52 400	9.0	55	M.G.	Own	(1)	G D	178	A.C.	Own	24-R L	200	1 200	230	A. (1)	16
:15	40 000	11.0	65						motor		D.B.				B (2))	
:16	37 000	12.0	71						driver							
:17	34 000	13.0	77													
:18	32 000	14.0	83													
:19	29 500	15.5	87													
:20	27 500	17.0	95													
:21	25 500	18.0	102													
:17	41 000	13.5	69	M.G.	G.E.	3-CD	W A B	262	26	G.E.	24-R L	360	1 650	490	None	20
:18	38 200	16.7	74								D.B.					
:20	35 000	18.2	80	M.G.	G.E.	3-CD	W A B	262	26	G.E.	24-R L	360	1 200	490	1 650	20
:22	31 000	20.6	91								D.B.					
:24	27 500	23.2	103													
:26	24 500	25.9	115													
:15	42 800	11.7	66.4	M.G.	W.	3-CD	W A B	262			24-R L	300	1 200	310	None	20
:17	37 200	13.5	76.5								D.B.					
:15	42 800	14.7	66.4	M.G.	W.	3-CD	W A B	262			24-R L	350	1 200	330	None	20
:17	37 200	16.9	76.5								D.B.					
:15	42 800	17.6	66.4	M.G.	W.	3-CD	W A B	262			24-R L	400	1 200	350	None	20
:17	37 200	20.2	76.5								D.B.					
:15	42 800	11.7	66.4	M.G.	W.	3-CD	W A B	262	∅	∅	24-R L	300	1 200	310	700	20
:17	37 200	13.5	76.5								D.B.					
:19	32 200	15.5	88.2													

SPECIFICATIONS OF DIE

ELECTRICAL EQUIPMENT							TRUCKS									
Generators				Traction mtr					Wheels				Journal brgs		
Main generator		Auxiliary generator		Total No. per unit	Type	Make	Type	Wheel base	Number driving (pairs)	Number idling (pairs)	Diam.	Min. curve radius	Type	Make	Si
Type	Make	Type	Make												
(27)	(28)	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)	(39)	(40)	(41)	(4
ROAD PASSENG															
Alco-G. E. (American Locomotive Co., and General Electric															
Baldwin Locomotive Works, Eddystone, Pennsylvania.															
471	W.	Y.G. 54-B	W.	4	370	W.	S.B.	15′-6″	2	1	42″	310°	R.B.	*	6 1 ×
Electro-Motive Division, General Motors Corporation, La Grange, Illinois.															
Comb. AC-DC (1)	Own	D.C. Shunt	D.	4	D.C. Series	Own	(1)	14′-1″	4	2	36″	274°	R.B.	H.	6 1 × I
Fairbanks, Morse & Co., Chicago, Illinois. (See also Models Alt. 100.3 (2.000 HP) — and CP 16-4 (1 600 HP) under Roa															
497	W.	Y.G. 54-B	W.	4	370	W.	S.B. (3) (2)	9′4″ (1) 15′-6″	4	1	42″	273°	R.B.	T.	6 1 ×
498	W.	Y.G. 54-A	W.	4	370	W.	S.B. (3) (2)	9′-4″ (1) 15′-6″	4	1	42″	273°	R.B.	T.	6 1 × I
498	W.	Y.G. 54-A	W.	4	370	W.	S.B. (3) (2)	9′-4″ (1) 15′-6″	4	1	42″	273°	R.B.	T.	6 1 × I

TRIC LOCOMOTIVES *(continued)*.

Exhibit « A »
Sheet 6 of 7

SPEED			AUXILIARIES								SUPPLIES				
			Starter		Air compressor			Traction motor blowers							
Cont. trac-tive effort (lbs.)	Cont. rat-ing MPH	Max. speed MPH	Type	Make	Type	Make	Capa-city (C.F.M.)	T.	M.	Air brake sched.	Lub. oil cap. (gals)	Fuel oil cap. (gals)	Eng. cool-ing water cap. (gals)	Htg. boiler water cap. (gals)	Sand cap. (cu. ft)
(44)	(45)	(46)	(47)	(48)	(49)	(50)	(51)	(52)	(53)	(54)	(55)	(56)	(57)	(58)	(59)
MOTIVES															
ectady, N. Y.) (Latest data not available at press-time.)															
42 800	14.5	65	Elec. Bty.	Gould or Exide	3-CD or W X O	W A B or G.D.	262 —	Mech. driven	S.	24-R L D.B.	340	1 200	550	1 450	30
37 200	16.8	75													
32 200	19.5	82													
30 000	20.7	87.5													
28 100	22.0	93.5													
26 400	23.0	100													
24 800	25.0	106													
23 300	26.5	113													
22 000	27.5	120													
27 000	26	85	M.G.	Own	(2)	G.D.	178	(1)	Own	24-R L D.B.	330	1 200	400	(3)	16
25 000	28	92													
23 500	30	98													
19 500	36	117													
otives).															
32 200	15.5	88.2	M.G.	W.	3-CD	W A B	262	∅	∅	24-R L D.B.	300	1 200	310	1 400	20
28 200	17.8	100.8													
24 800	20.2	114.4													
32 200	19.5	88.2	M.G.	W.	3-CD	W A B	262	∅	∅	24-R L D.B.	350	1 200	330	1 400	20
28 200	22.4	100.8													
24 800	25.4	114.4													
32 200	23.4	88.2													
28 200	26.8	100.8													
24 800	30.4	114.4													

SPECIFICATIONS OF

ELECTRICAL EQUIPMENT							TRUCKS							
Generators				Traction mtr					Wheels				Journl b	
Main generator		Auxiliary generator		Total No. per unit	Type	Make	Type	Wheel base	Number driving (pairs)	Number idling (pairs)	Diam.	Min. curve radius	Type	Mak
Type (27)	Make (28)	Type (29)	Make (30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)	(39)	(40)	(41)
COMBINATION ROAD-SW														
Alco-G. E., Schenectady, N. Y. (Latest data not available at press time.)														
Baldwin Locomotive Works, Eddystone, Pennsylvania.														
471	W.	Y.G. 42-B	W.	4	370	W.	S.B.	9′-10″	4	None	42″	30°	S.	*
471	W.	Y.G. 42-B	W.	4	370	W.	S.B.	9′-10″	4	None	42″	30°	S.	*
471	W.	Y.G. 42-B	W.	4	370	W.	S.B.	11′-6″	4	2	42″	30°	S.	*
471	W.	Y.G. 42-B	W.	4	370	W.	S.B.	11′-6″	4	2	42″	30°	S.	*
471	W.	Y.G. 42-B	W.	6	370	W.	Rigid	13′-0″	6	None	42″	30°	S.	*
471	W.	Y.G. 42-B	W.	6	370	W.	Rigid	13′-0″	6	None	42″	30°	S.	*
480	W.	Y.G. 42-B	W.	6	370	W.	Rigid	13′-0″	6	None	42″	30°	S.	*
480	W.	Y.G. 42-B	W.	4	362	W.	S.B.	9′-10″	4	None	42″	30°	S.	*
480	W.	Y.G. 42-B	W.	4	362	W.	S.B.	9′-10″	4	None	42″	30°	S.	*

Abbreviations and notes :

Col. 27 : (1)—A.C. generator—variable frequency; (2)—D.C. traction generator, fully compensated.
Col. 28 and 30 : W Westinghouse; D—Delco.
Col. 34 : S.B.—Swing bolster; (1)—Flexible with outside swing hangers; (2)—Swing bolster, fully compensated; (3)—Swing bolster, drop equalizer
Col. 35 : (1)—front 4-wheel truck; (2)—rear truck.
Col. 40 : R.B.—roller bearing; S—solid bearin
Col. 41 : *—optional.
Col. 47 : M.G.—main generator.
Col. 49 : (1)—2 stage, 3 cylinder, air cooled

C LOCOMOTIVES *(continued)*.

Exhibit « A »
Sheet 6 of 7

SPEED			AUXILIARIES								SUPPLIES				
			Starter		Air compressor			Traction motor blowers							
ont. rac- ive fort bs.)	Cont. rat- ing MPH	Max. speed MPH	Type	Make	Type	Make	Capa- city (C.F. M.)	T.	M.	Air brake sched.	Lub. oil cap. (gals)	Fuel oil cap. (gals)	Eng. cool- ing water cap. (gals)	Htg. boiler water cap. (gals)	Sand cap. (cu ft)
44)	(45)	(46)	(47)	(48)	(49)	(50)	(51)	(52)	(53)	(54)	(55)	(56)	(57)	(58)	(59)
FER) LOCOMOTIVES															
2 800 7 200 2 200	10.5 12.2 14.0	65 75 82	Elec. Bty.	Gould or Exide	3-CD or W X O	W A B G D	—	Mech.	S.	6-DS D.B.*	200	900	300	None (4)	30
2 800 7 200 2 200	10.5 12.2 14.0	65 75 82	Elec. Bty.	Gould or Exide	3-CD or W X O	W A B G D	—	Mech.	S.	6-DS D.B *	200	1 000	300	900	30
2 800	10.5	65	Elec. Bty.	Gould or Exide	3-CD or W X O	W A B G D	—	Mech.	S.	6-DS D.B. *	200	900	300	None (4)	30
2 800	10.5	65	Elec. Bty.	Gould or Exide	3-CD or W X O	W A B G D	—	Mech.	S.	6-DS D.B. *	200	1 000	300	900	30
4 200	6.6	60	Elec. Bty.	Gould or Exide	3-CD or W X O	W A B G D	—	Mech.	S.	6-DS D.B. *	200	1 900	300	None (4)	30
4 200	6.6	60	Elec. Bty.	Gould or Exide	3-CD or W X O	W A B G D	—	Mech.	S.	6-DS D.B. *	200	1 000	300	900	30
4 200	9.4	60	Elec. Bty.	Gould or Exide	3-CD or W X O	W A B G D	—	Mech.	S.	6-DS D.B. *	340	1 500	500	None	45
2 400	9.5	60	Elec. Bty.	Gould or Exide	3-CD or W X O	W A B G D	—	Mech.	S.	6-DS D.B. *	170	900	250	None (4)	30
2 400	9.5	60	Elec. Bty.	Gould or Exide	3-CD or W X O	W A B G D	—	Mech.	S.	6-DS D.B. *	170	1 000	250	900	30

2 stage, 2 cylinder, water cooled.
) : WAB—Westinghouse Air Brake; G.D.—
ner Denver.
: (1)—Vane type, engine driven; (2)—Niagara
3.
: S—Sturtevant.
4 : D.B.—dynamic braking; D.B. *—dynamic braking available if no boiler is applied.

Col. 58 : (1)—A-unit Vapor 800 gals when dynamic brakes not supplied; (2)-B-unit Vapor 2 000 gals when dynamic brakes not supplied; (3)—Vapor 1 950 gals when dynamic brakes not supplied; (4)—Boiler and water can be applied as a modification; (5)—Heating water increases weight given.

B. A

8. *Name of the system of drive.*
9. *On how many vehicles is this system installed?*
   Commencing year.
   Arrangement of axles.
10. *Types under construction or in design, number of vehicles.*

ADMINISTRATION		Electric locomotives	Diesel electric
London Transport Executive	Name of system of drive.		
	No. of vehicles in service: Tube / Surface Commencing year: Tube / Surface Arrangement of axles: Tube / Surface Types and No. under construction: Tube / Surface		
British Railways (Southern Region)	Name of system of drive.	Non resilient straight spur gear and pinion drive from axle hung, nose suspended motor.	
	No. of vehicles in service.	3	
	Commencing year.	1945	
	Arrangement of axles.	Co + Co	
	Types and No. under construction.	None.	
British Railways (Eastern Region)	Name of system of drive.		
	No. of vehicles in service and commencing year.		
Ceylon Government Railways	Name of system of drive.		
	No. of vehicles in service. Commencing year. Arrangement of axles. Types and No. under construction.		

ıl drive.

ıtiple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
ɜsilient helical gear pinion drive from hung, nose suspen- traction motor. ;50 motor cars. !55 motor cars. 1938 1936 – Ao + Ao — 1 — 1 + 1 — Ao with similar drive. with similar drive.			
esilient straight spur r and pinion drive n axle hung, nose ɔended motor. 1073 1915 Bo + 2 None.			
ht spur gear with ɜ hung motor. 2 (Tydeside Lines). 92 (L'pool St.-Shenf.)			
	Non resilient straight spur gear and pinion drive from axle hung, nose suspended motor. 12 cars 1938 None.	Non resilient straight spur gear and pinion drive from axle hung, nose suspended motor. 11 cars 1947 None.	

ADMINISTRATION		Typ	
		Electric locomotives	Diesel electric locomoti
Pennsylvania Railroad	Name of system of drive.	Geared quill drive by frame mounted motors with resilient drive to axle by rubber cups or springs.	Non resilient straight s gear and pinion d from axle hung r suspended motors
	No. of vehicles in service — Passenger	139	114
	No. of vehicles in service — Freight	92	251
	Commencing year — Passenger	1930	1945
	Commencing year — Freight	1931	1947
	Arrangement of axles — Passenger	2 — C + C — 2	A — 1 — A + A — 1 —
	Arrangement of axles — Freight	2 — C — 2	B - B
	No. under construction.	4	
British Railways (London Midland Region)	Name of system of drive.		
	No. of vehicles in service.		
	Commencing year.		
	Under construction.		
	Arrangement of axles.		
Victorian Government Railways	Name of system of drive.		
	No. of vehicles in service.		
	Commencing year.		
	Arrangement of axles.		
	Under construction.		

le

ʌultiple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric Shunters
ilient straight spur gear nd pinion drive from xle hung nose suspen- ed motors (resilience btained with springs).		Non resilient straight spur gear and pinion drive from axle hung,nose suspended motors.	Non resilient straight spur gear and pinion drive from axle hung,nose suspended motors.
385		22	428
1914		1925	1937
2 — B or B — 2		2 — B or B — 2	B — B
50			19
; hung nose suspended otors with single reduc- on gear. 59 motor cars. 1939 None Bo — Bo			
: hung nose suspended otors with single re- iction gear. 403 1919 — Nil			

11. General arrangement drawings of the drive.

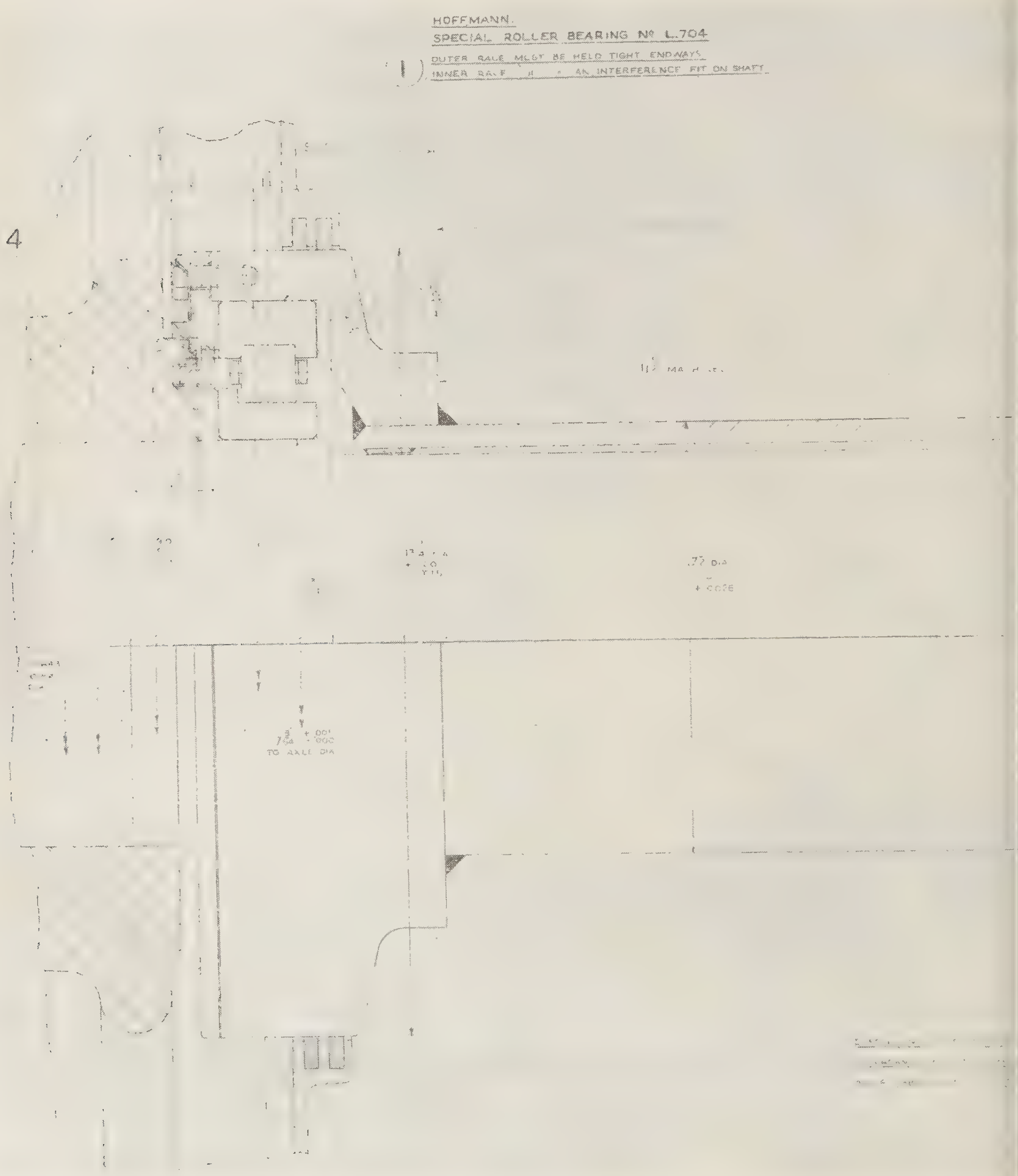
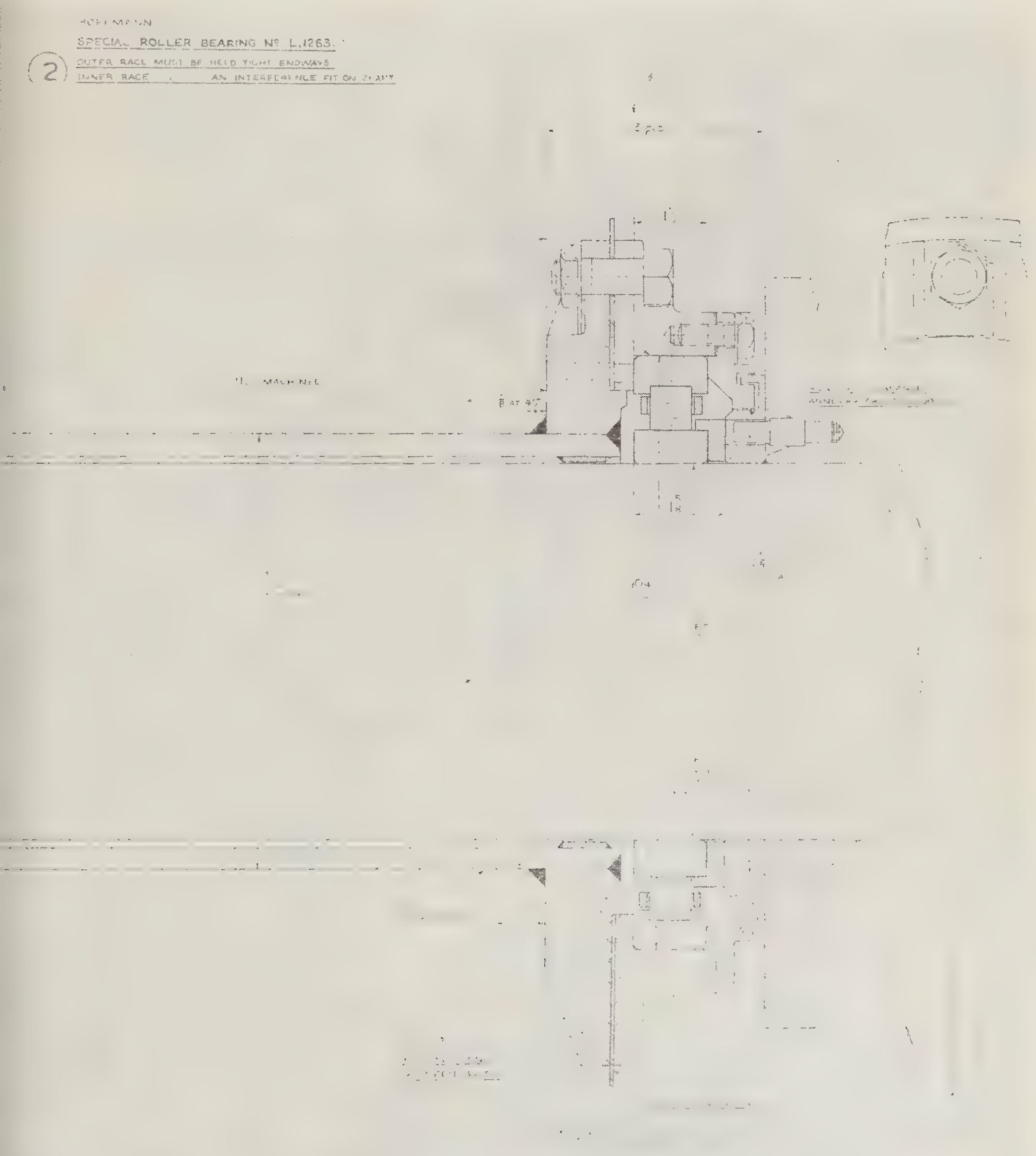


Fig. 1. — Roller bearing suspension sleeve, « E



Transport Executive.)

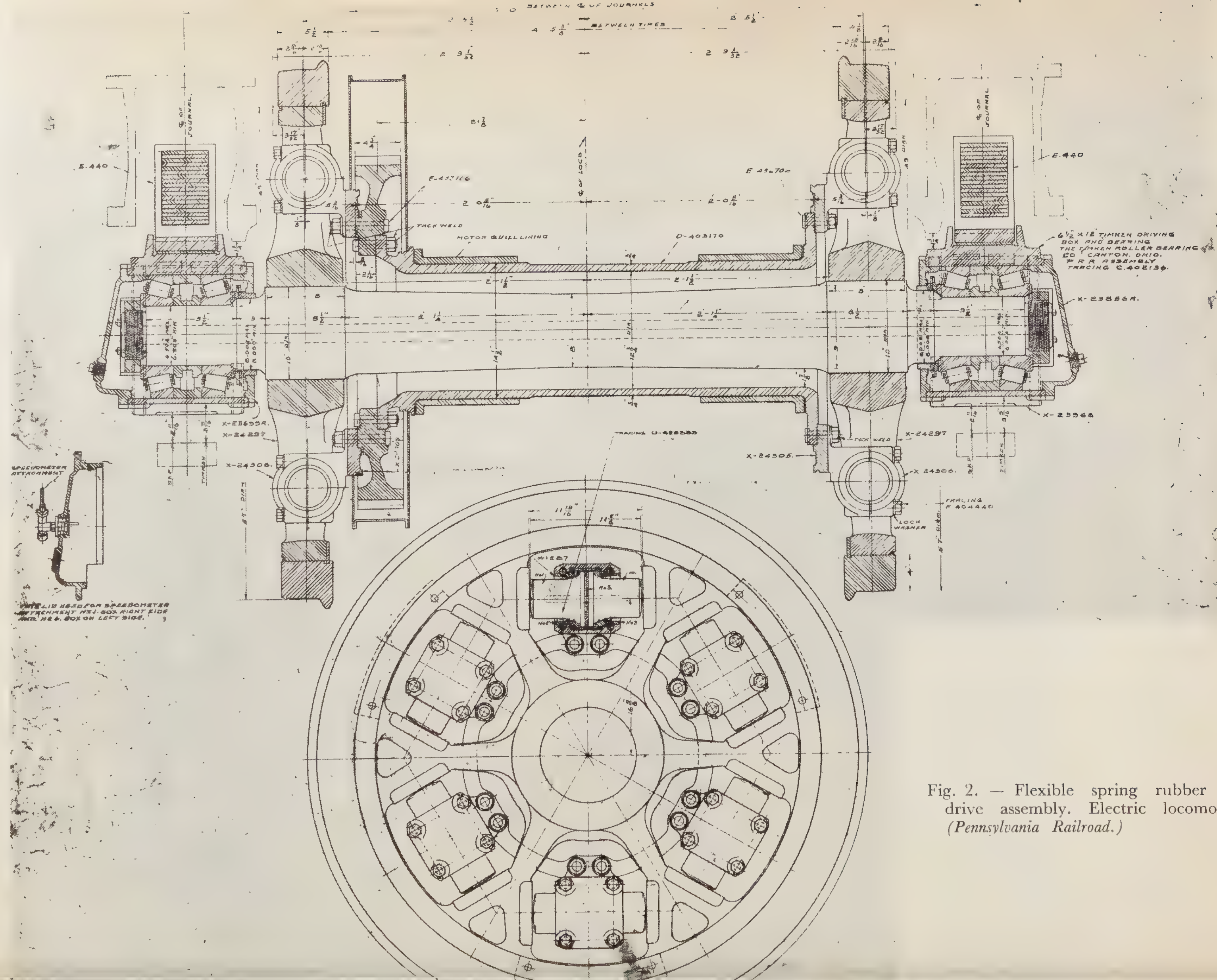


Fig. 2. — Flexible spring rubber unit drive assembly. Electric locomotives. *(Pennsylvania Railroad.)*

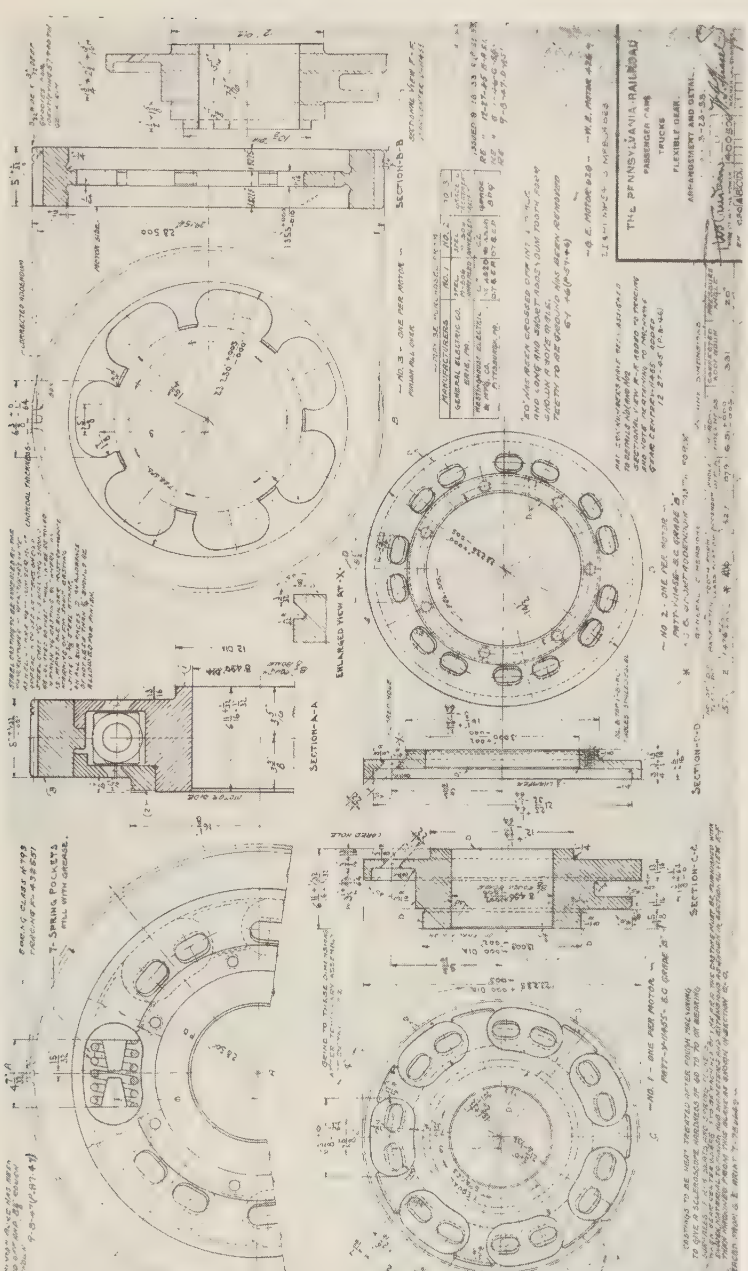


Fig. 3. — Flexible gear arrangement. Multiple unit motor car. *(Pennsylvania Railroad.)*

12. *One hour torque at the maximum speed in service and under maximum tractive effort.*
14. *What is the arrangement restraining the lateral movement of the motor?*
15. *Vertical forces due to the drive.*
16. *Transverse play of the axles in relation to the bogie.*
17. *Angular play in the horizontal plane of the axles in relation to the bogie.*

ADMINISTRATION		Typ	
		Electric locomotives	Diesel electric locomo
London Transport Executive	One hour torque. *a*) A 1 hr. speed { Tube / Surface *b*) Max. torque at max. speed { Tube / Surface *c*) Torque at max. T. E. { Tube / Surface Method of restraining lateral movement of motor. Vertical forces due to drive (torque react.) { Tube / Surface Transverse play of axle in relation to bogie. Angular play (horizontally).		
British Railways (Southern Region)	One hour torque at 1 hour rating. Method of restraining lateral movement of the motor. Vertical forces due to drive. Transverse play of axle in relation to bogie. Angular play (horizontally).	126 000 kg/cm. White metal collars on axle mounted motor suspension bearings acting on wheel centre bosses. No information available 1st & 3rd axles 2nd axle. Normally 1.5 mm 20 mm Maximum 4.5 mm 25.4 mm —	
British Railways (Eastern Region)	One hour torque at max. speed. Method of restraining lateral movement of motor. Vert. force due to drives, Transverse play of axle angular play.		

ehicle			
Iultiple unit electric motor cars	Multiple ùnit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
15 300 kg/cm 15 200 kg/cm 1 475 kg/cm 1 640 kg/cm 22 450 kg/cm 21 850 kg/cm motor case is bolted gidly to the suspension eeve which runs on rol- bearings mounted at ch end. Side play aries between .25 mm id .38 mm. que at wheel tread) /191 kg que at wheel tread) /239 kg Normally 5 mm Maximum 9 mm 0° 16′			
35 000 kg/cm te metal collars on le mounted motor sus- nsion bearings acting wheel centre bosses. information available. Normally 3.18 mm. Iaximum 6.36 mm. —			
— ist faces of suspension arings. — 6 220 kg max. 4 mm 0° 5′ (Total)			

ADMINISTRATION		Electric locomotives	Diesel electric loco
Ceylon Government Railways	One hour torque. Method of restraining lateral movement of the motor. Vertical forces due to drive. Transverse play of axle. Angular play of axle.		
Pennsylvania Railroad	One hour torque. Method of restraining lateral movement of motor. Vertical forces due to drive. Transverse play of axle in relation to bogie (Total). Angular play of axle.	Not determined. Motor fixed to loco. frame. No information available. 9.5 mm 6′ max.	Not determined. Inside of wheel h — 9.5 mm 6′ max.
British Railways (London Midland Region)	One hour torque. Method of restraining lateral movement of motor. Vertical forces due to drive. Transverse play of axle in relation to bogie. Angular play horizontally.		
Victorian Government Railways	One hour torque at : *a*) 1 hour rating. *b*) maximum speed. *c*) maximum T. E. Method of restraining lateral movement of motor. Vertical forces due to drive. Transverse play of axle in relation to bogie. Angular play horizontally.		

hicle			
Iultiple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
information available. tor supported on bear- ngs mounted on the axle.		No information available. Motor supported on bearings mounted on the axle.	
information available.		No information available.	
3.175 mm			
—		—	
t determined. ide of wheel hub.		Not determined. Inside of wheel hub.	Not determined. Inside of wheel hub.
—		—	—
9.5 mm		9.5 mm	9.5 mm
18′ max.		18′ max.	18′ max.
—			
nges and collars on uspension bearings.			
—			
6.35 mm (normally). 6.8 mm (maximum).			
—			
49 400 kg/cm			
6 670 kg/cm			
76 200 kg/cm			
nged suspension bearings.			
pension bgs. ± 3.090 kg			
tor nose ± 2.100 kg			
(Total) 6.35 mm			
0° — 15′ — 30″			

13. *Details of the maintenance work on the drive — maintenance intervals.*
18. *Have you given up some arrangements of drive? Which and for what reason and from what date?*

ADMINISTRATION		Ty	
		Electric locomotives	Diesel electric locor
London Transport Executive	Lubrication. Inspection. Overhaul. Details of overhaul. Drives given up.		
British Railways (Southern Region)	Lubrication. Bearing clearances checked. Drives given up.	As required. 160 900 km None.	
British Railways (Eastern Region)	Maintenance. Drives given up.		
Ceylon Government Railways	Lubrication. Overhaul. Drives given up.		
Pennsylvania Railroad	Lubrication. Inspection : Passenger Freight Overhaul : Passenger Freight Details of overhaul. Drives given up.	As required. Monthly. Monthly. 650 000 km 610 000 km The following parts are renewed as necessary : Driving cups or springs, rings, wearing plates, wheel centres, spiders, quills, pinions, etc. (1) March (4 pin flexible link). (2) Buchli (link). (3) Milwaukee. (4) Balanced yoke (inverted flexure). (5) Geared jack shaft. These were given up due to difficulty of mainte Since 1946 rubber cups have been substitut of the rubber does not damage the rest of the	As required. 225 000 km 129 000 km 1 609 000 km 1 609 000 km Gears and pini renewed as n None.
British Railways (London Midland Region)	Lubrication. Drives given up.		
Victorian Government Railways	Maintenance. Drives given up.		

iple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
s. every 12 weeks. Monthly. 321 800 km nd pinions are re- l as necessary. ;ht spur gears re- l by helical in 1935.			
\s required. 160 900 km None.			
— None.			
	Weekly. 1 500, 4 500 & 6 000 h. as per schedule. None.	Weekly. 1 500, 4 500 & 6 000 h. as per schedule. None.	
— 8 100 km 4 years. — llowing parts are ed as necessary : pinions, centres, ing plates, etc. None.	—	— Monthly & 81 000 km 4 years. — Gears and pinions are renewed as necessary. None.	— Monthly & annually. — — Gears and pinions are renewed as necessary. None.
ıad no basic advantage over simpler types. ;s in the existing quill drive because wearing			
;reased at 50 day nation. None.			
c fracture test at ly intervals. None.			

19. *Results obtained with the driving arrangements (maintenance, purchase price and behaviour).*

ADMINISTRATION		Typ	
		Electric locomotives	Diesel electric loco
London Transport Executive	Present drive-maintenance. Purchase price { Tube Surface		
British Railways (Southern Region)	Present drive : Maintenance. Purchase price. Behaviour.	Very low. — Very good.	
British Railways (Eastern Region)	Present drive.		
Ceylon Government Railways	Present drive.		
Pennsylvania Railroad	Present drive. Cost.		The present dri unknown.
British Railways (London Midland Region)	Present drive. Maintenance. Purchase price.		
Victorian Government Railways	Present drive. Maintenance. Purchase price.		

iple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
ieral trouble has experienced with of modern design. roller bearing sus- on sleeves wear on eeth has been mar- less, provided that terchange between und pinion is allow- £ 6 Gear £ 27. £ 6 Gear £ 33.			
Very low. — Very good.			
Satisfactory.			
—			
dered to be generally satisfactory.			
— — —			
tory & trouble free. Unknown.			

20. *What is your experience of the riding of the motor vehicles on the road (where it concerns the cons Department? If not, what is the point of view of the Permanent Way Department? What is that of t*

ADMINISTRATION		T	
		Electric locomotives	Diesel electric loco
London Transport Executive	*Riding.* As affected by type of drive. *a*) C. M. E. Dept. *b*) P. W. Dept.		
British Railways (Southern Region)	*Riding.* As affected by type of drive. *a*) C. M. E. Dept. *b*) P. W. Dept.	 Very good. Averse to unsprung weight.	
British Railways (Eastern Region)	*Riding.* As affected by type of drive. *a*) C. M. E. Dept. *b*) P. W. Dept. (i) Tyneside. (ii) Liverpool St.-Shenf.		
Ceylon Government Railways	—		
Pennsylvania Railroad	—		
British Railways (London Midland Region)	*Riding.* As affected by type of drive *a*) C. M. E. Dept. *b*) P. W. Dept.		
Victorian Government Railways	*Riding.* As affected by type of drive. *a*) C. M. E. Dept. *b*) P. W. Dept.		

lual drive)? Does your reply on the subject take account of the point of view of the Permanent Way epartment?

ple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
per bogie is con- l superior to 2. C. G. & unsprung is considered to se impact shock at ints which causes bolster oscillation. f motored vehicles idered to be harsh- in trailer vehicles ack wear is greater.			
Very good. o unsprung weight.			
atisfactory. atisfactory. isceptible to bad			
—			
—			
— —			
nparison can be as there is only ype in use.			

21. *What are the proved advantages or disadvantages from the point of view of the maintenance of the tra*
What is the influence of the diameter of the wheels on the deterioration of the track at high speeds?
22. *Have you yet made tests of the vehicles while running and measured forces between wheel and rail*
1. With nose suspended motor. — 2. With motor having flexible drive.
What are the results of these tests and method of measurement?
Can you give sources of data concerning theoretical calculations of the forces between rail and wheel o
(See also

ADMINISTRATION		Electric locomotives	Diesel electric loco
London Transport Executive	Effect of electric vehicle on track maintenance. Wheel size. Tests.		
British Railways (Southern Region)	Effect of electric vehicle on track maintenance. Wheel size. Tests.	Track wear is greater due to increased service intensity and to higher load/dia. ratio of motored wheels. — None.	
British Railways (Eastern Region)	Effect on track. Wheel size. Tests.		
Ceylon Government Railways	—	—	
Pennsylvania Railroad	Effect of electric vehicles on track maintenance. Wheel size. Tests.	It is considered that track maintenance less wheel slip. For larger wheels the stress in both the wh See « exhibit B » « Brinell Hardness T It would appear from this test that a lateral	
British Railways (London Midland Region)	Effect of electric vehicle on track maintenance. Wheel size Tests.		
Victorian Government Railways	Effect of electric vehicles on track maintenance. Wheel size.		

of electric motor vehicles?

such calculations or results of tests to your reply?
nd 60.)

tiple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
pears that electric requires a higher e of track mainten- than steam stock he same degree of ort. wheels give less joint shock. None.			
wear is greater due creased service in- ty & to higher load/ ratio of motored ls (SR. Appendix.) None.			
— None.			
—			
ctric vehicles as compared with reciprocating steam locos due to absence of dynamic augment and ed. These stresses increase with speed, due to impact at rail joints. s advantageous in reducing lateral forces.			
comparable data. comparable data. None.			
is greater due to eased acceleration braking rates. —			

Attachment to
Questions 22 and 60.

EXHIBIT « B »

The Pennsylvania Railroad.

In connection with electric road locomotives only, which locomotives have motors with flexible drive, track tests at intervals from the year 1933 to 1938 were conducted to determine just what action was occurring with the various designs of these locomotives in damaging the track by excessive lateral blows. The data from these tests are voluminous. Brinell track test and electric strain gauge tests were run.

The Brinell Test Track was installed at Claymont, Del. It consisted of a stretch of track 440 feet long, laid on steel ties, in which all the lateral support for the rail passes through hard steel balls bearing against soft steel impression plates. The lateral force against the rail is measured by the depth of the impression that each ball makes in the soft steel plates. The track was deliberately made very rough in order to represent a track condition that might conceivably exist some time in the future and result in the rail being pushed out of line by locomotives of undesirably high lateral thrust characteristics. The track condition was admittedly artificial, the roughness consisting of vertical humps which were plainly seen. In actual track unusual roughness is usually the result of soft spots which are not particularly noticeable but which become vertical depressions under the weight of a passing locomotive.

A comparison of the locomotives tested over the Brinell test tracks was determined by the speeds at which the various locomotives produced a maximum depth of impression of 0.05 inch, which was arbitrarily set as the limit beyond which it was not advisable to go.

These tests show clearly the improvement in the running qualities of the modern electric locomotives over those of the older ones such as the original 01c and P5*a* locomotives (referred to in tabulated answer to Question 6) built in 1931 and 1932 respectively. When these locomotives were modified by changing their equalization and increasing the lateral resistance of the engine trucks, by lateral resistance type bolsters and the truck coupled in the lateral plane by a spring cushioned restraint arrangement, their speed was increased about 20 m.p.h. for the same lateral blow on the track.

A P5*a* locomotive experimentally equipped with a lateral motion cushioning device at the front and rear driving boxes dit not show as good a performance over the Brinell track as it did without this device.

Another series of tests was made using electric strain gauges which, instead of measuring the lateral pressure at the rail, the lateral pressure between the frames and wheels was measured. This lateral pressure bent a small weight bar, the strain in which operates an electric strain gauge and is recorded by an oscillograph.

Continuous measurements were obtained over selected stretches of track between Wilmington and New York aggregating about 60 miles in length and the results reduced to the basis of a 200 mile run for comparison.

The force measured at the wheel hub should correspond to that produced at the rail head, except such force as is required to overcome the inertia of the wheels and axle. If the force is of short duration it is possible that a large part of it is used to overcome the inertia of the wheels and axles and never reaches the rail. Nevertheless the strain gauge method probably gives a fair comparison of the forces produced on the rail over which different test locomotives were run. These tests were made over track that was satisfactory for high speed operation, and was much smoother than the Brinell Test Track.

At times, the only comparison possible between different locomotives was based on strain gauge tests run in different years, and analysis of the records indicates that there was considerable difference in the condition of the track when the two runs were made.

A comparison of all the locomotives tested by this method was on the basis of the number of blows for each magnitude of blow from 16 000 lbs. to 40 000 lbs. in increments of 2 000 lbs. made on a 200 mile run by each locomotive. All runs except those of the P5*b* were made at a constant speed of 90 m.p.h. The P5*b* was run at 70 m.p.h., its maximum speed.

The results indicated that the GG1 locomotive was a little better than the DD2, and DD2 considerably better than the P5*a*.

The P5*b* when tested at 70 m.p.h., its maximum speed, was a little better than the P5*a* running at 90 m.p.h.

The P5*a* with the experimental lateral cushioning device at the front and rear driver boxes was much better than the P5*a* tested without it at the same time. This comparison was not confirmed by the tests over the Brinell track, but it should be noted that the Brinell Track was very rough while the strain gauge tests were run over comparatively smooth track. It is quite possible that the small amount of cushioning provided by the experimental device on the P5*a* would be very effective on track in good condition but is not large enough to be of much value when tested over the rough Brinell Test Track. We can give no sources of data concerning theoretical calculations.

Attachment to
Questions 22, 58 and 59.

APPENDIX 1.

British Railways (Southern Region).

Maximum wheel/rail contact pressure produced by maximum static working loads.

Type of locomotive or stock	Wheel	Wheel load P tons	Dia. of wheel d inches	$\frac{P}{d}$ Ratio	Maximum contact surface pressure (radius of rail head = 9″ and unworn tyre) tons per square inch.
Steam stock.					
Merchant Navy. (Nos. 35011-35020)	Tender 3	9. 2	43	.214	80.2
B. 4	Driver 2	9. 23	45.75	.202	78.9
C. 14	Driver 1	6. 6	36	.1835	75.8
T. 14	Tender 1	7. 65	43	.178	75.5
H. 16	Trailing pony	7. 5	43	.175	75.0
H. 15	Tender 1	7. 37	43	.172	74.5
1.3	Trailing pony	8. 38	48	.175	74.3
E6/X	Driver 2	8. 88	54	.1645	74.3
0415	Trailing pony	6. 2	36	.172	74.2
V (Schools)	Bogies	6. 28	37	.17	73.8
Z	Drivers	8. 95	56	.16	73.8
G. 6	Driver 3	9. 1	58	.157	73.0
S. 15	Drivers	10. 0	67	.149	72.5
C. 16	Driver 2	9. 25	61	.152	72.4
Q. 1	Driver 2	9. 13	61	.15	72.0
Merchant Navy	Drivers	10. 5	74	.142	71.6
H. 15	Driver 2	10. 1	72	.1402	71.3
V. (Schools)	Driver	10. 5	79	.133	70.6
Q	Tender 1	6. 88	48	.144	70.3
Lord Nelson	Driver	10. 33	79	.131	70.3
— do —	Bogies	5. 39	37	.146	70.1
0458	Driver 2	5. 43	38	.143	69.8
T. 1	Trailing bogie	5. 13	36	.1426	69.6
N. 15 (King Arthur) ...	Driver	10. 0	79	.126	69.5
— do —	Bogies	5. 5	43	.128	67.6
Merchant Navy	Bogies	4.175	37	.113	64.4
Electric stock.					
Units 3001-3020 Brighton Main Line	Motor bogies	8. 62	42	.205	79.1 (100% overload)
— do	— do —	8. 35	42	.199	78.6 (50% overload)
Units 3073 - 3085 Portsmouth Main Line	— do —	8. 34	42	.199	78.6 (100% overload)
— do	— do -	8. 08	42	.193	77.7 (50% overload)
— do —	— do -	7. 82	42	.186	76.6 (full load)
Units 2001-2152 Suburban	Motor bogie	8. 02	42	.191	77.3 (100% overload)
— do —	— do —	7. 75	42	.185	76.6 (50% overload)
Electric loco C. C. I.	—	8. 37	43	.195	—

Attachment to
Questions 22, 58 and 59.

British Railways (Southern Region).

We have not carried out any laboratory tests to measure the static contact pressures, but in order to compare the maximum dynamic loads applied to rails by multiple unit motor bogie wheels and main line steam locomotive wheels at similar speeds, an analysis has been made of the results of tests carried out at Byfleet by the Building Research Station in March 1948, for the purpose of recording under traffic the bending stresses in head and foot at various parts of a rail, and the web stresses at joints.

Electrical resistance strain gauges were fixed to the rails at 17 different positions on each of four rails, and some 2 800 strain values were measured from the oscillograph records.

Since the bending stresses in a rail are roughly proportional to the single wheel loads producing them, it was possible for each of the 17 gauge positions to compare the heaviest dynamic loads applied by the electric motor bogie wheels with those applied by steam locomotive wheels running over the same locations at roughly the same speed. These ratios (electric/steam) were found to vary between 1.021 and 0.480, the average being 0.726.

Taking the respective wheel diameters into account and assuming new tyres in all cases for uniformity of comparison, the corresponding electric/steam ratios of maximum contact pressures were found to lie between 1.203 and 0.756, the average being 1.099, i. e. the maximum contact pressures applied by the motor bogie wheels were on the average 10 % higher than those applied by the locomotive wheels.

No corresponding results for electric locomotives were obtained during this test.

With regard to the request for « source of data ». Attached as Appendix 2 are the calculations (and graph referred to therein) by which the contact pressures have been obtained.

Attachment to
Questions 22, 58 and 59.
APPENDIX 2.

Fundamental principles.

If two bodies having the same Modulus of Elasticity E and Poisson's ratio σ bear one upon the other with a force of P tons, and if the principal radii of curvature of the surfaces at the point of contact are for one body r_1 and $r^1{}_1$ and the other r_2 and $r_2{}^1$, and Φ the angle between the planes containing the principal radii r_1 and r_2 then the theoretical shape of the area of contact is an ellipse whose semi axes « a » and « b » have for expression

$$a = \alpha . \sqrt[3]{\frac{Pm}{n}} \qquad b = \beta . \sqrt[3]{\frac{Pm}{n}}$$

where $m = \dfrac{4}{\dfrac{1}{r_1} + \dfrac{1}{r_1{}^1} + \dfrac{1}{r_2} + \dfrac{1}{r_2{}^1}}$ and $n = \dfrac{4\ E}{3\ (1 - \sigma^2)}$

and where α and β have values expressed by the graph in fig. 1 in function of the angle θ

$$\text{when } \cos\theta = \frac{m}{4}\sqrt{\left(\frac{1}{r_1} - \frac{1}{r_1{}^1}\right)^2 + \left(\frac{1}{r_2} - \frac{1}{r_2{}^1}\right)^2 + 2\left(\frac{1}{r_1} - \frac{1}{r^1{}_1}\right)\left(\frac{1}{r_2} - \frac{1}{r_2{}^1}\right)\cos 2\,\Phi}$$

The radii of curvature are considered as positive when the centre of curvature is to be found at the interior of the body under consideration.

The maximum vertical pressure at the centre of the surface of contact is

$$P_{max} = \frac{3}{2} \cdot \frac{P}{\pi . ab}$$

Applying these principles to the contact between an unworn tyre and a rail :

r_1 = radius of running surface of rail head (Average 9″ whether new or worn).
$r^1{}_1 = \infty$
r_2 = radius of tyre (inches)
$r^1{}_2 = \infty$

so that $m = \dfrac{4}{\dfrac{1}{9} + \dfrac{1}{r_2}}$

and $\cos\theta = \dfrac{m}{4}\left(\dfrac{1}{9} - \dfrac{1}{r_2}\right) = \dfrac{\dfrac{1}{9} - \dfrac{1}{r_2}}{\dfrac{1}{9} + \dfrac{1}{r_2}}$

Also E = 13 200 tons per sq. inch.
and $\sigma = 0.3$

so that $n = \dfrac{4 \times 13\,200}{3\ (1 - 0.09)} = 19\,340$

Hence for any value of r_2, θ can be calculated and the values of α and β obtained from the graph.

Hence the values of a and b can be calculated, and substituted in the formula :

$$P_{max.} = \frac{3}{2} \cdot \frac{P}{\pi ab}$$

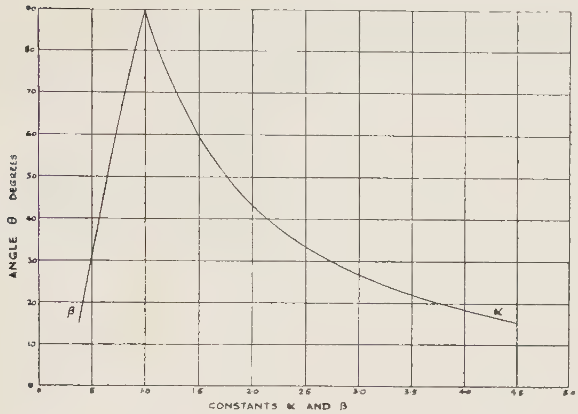


Fig. 4.

Questions Nos. 22 and 60.

Sources of data concerning forces between rail and wheel.

1. Bulletin of the I. R. C. A., December 1937.
2. Proceedings of the American Railroad Association. Vol. 46, 1945.
3. « Movement of Railway Vehicles on the Track and forces arising therefrom ». Institution of locomotive engineers. (Paper read 31-10-1945).
4. « Rail and Wheel ». W. C. Cushing. A. R. E. A. Bulletin No. 315 — Chicago, 1929.
5. « Adhesion and friction in Rail Traction » — Koffman. Institution of Locomotive Engineers' Journal, 1948.
6. A. R. E. A. Track Stresses Reports 1 — 6. Chicago, 1933.
7. India Railway Department — Track Stress Research. Progress Reports Vols. I and II. Calcutta, 1939.
8. Introduction to Railway Mechanics. — V. G. Lomonossoff. (O. V. P.), 1933.
9. Hammer Blow in Locomotives. — Colam and Watson. (Proc. I. M. E., (London) Vol. 146 — 1941.)
10. Mechanics of a Locomotive on a Curved Track. — Porter. (Proc. I. M. E. (London) Vol. 126 — 1934.)
11. Problems of Railway Mechanics. — G. V. Lomonossoff. (Proc. I. M. E. (London) Vol. 120 — 1931.)
12. Mastering Momentum. — L. K. Sillcox. (Simonds and Boardman, 1941).
13. Vibration of Road and Rail Vehicles. — B. S. Cain. (Pitman — New York).
14. Lateral Oscillation of Railway Vehicles. — R. D. Davies. (Proc. I. C. E. (London) Vol. II, Feb. 1939.)

23. *What is the trend of your ideas for the future?*
24. *Have you any special remarks to make?*

ADMINISTRATION		Electric locomotives	Diesel electric loco
London Transport Executive	Trend of future ideas.		
British Railways (Southern Region)	Trend of future ideas.	A flexible drive is desirable for speeds over 121 km/h.	
British Railways (Eastern Region)	Trend of future ideas.		
Ceylon Government Railways	Trend of future ideas.		
Pennsylvania Railroad	Trend of future ideas.	A trend towards axle hung motors owing to ease of maintenance.	
British Railways (London Midland Region)	Future trends.		
Victorian Government Railways	Future trends.		

cle			
›le unit electric ıotor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
n reduction of ng weight consist- h minimum cost, um reliability and maintenance.			
drive is desirable 21 km/h.			
'o change.			
	To expand Diesel service.		
No change from present practice (axle hung motors)			
implicity of nose ded motor as far ıible.			
unit stock with ıspended traction .			

25. *Do you prefer, from the point of view of the transmission and its maintenance, inside or outside axleboxes?*
26. *Do you consider that the motor should be placed as low as possible or that it would be better above the moto*

ADMINISTRATION		Electric locomotives	Diesel electric lo
London Transport Executive	Axle boxes. Motor position.		
British Railways (Southern Region)	Axle boxes. Motor position,	With axle mounted motors, only outside axle boxes are possible. The motors should be as low as possible.	
British Railways (Eastern Region)	Axle boxes. Motor position.		
Ceylon Government Railways	Axle boxes. Motor position.		
Pennsylvania Railroad	Axle boxes. Motor position.	Outside axle boxes are used for accessibil Preference for motor at axle level, but in	
British Railways (London Midland Region)	Axle boxes. Motor position.		
Victorian Government Railways	Axle boxes. Motor position.		

le			
tiple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
axle boxes for sibility and space iotors and drive. gies under vehicles, rs must be low.			
le mounted motors outside axle boxes ossible. otors should be as is possible.			
boxes for easy s. as possible.			
Outside. ow as possible.		Outside. As low as possible.	
for motors and drive. located slightly above axle.			
Outside. —			
. The only prac- fitting with nose nded motors. otors on existing are at axle level. not known.			

27. *Number of vehicles which employ this type of drive* : a) *Locomotives* { *Goods* / *Passenger* — *In 1940. In 1949. N*
b) *Electric motor cars . . . .*
c) *Diesel electric rail cars . . . .*

ADMINISTRATION		Electric locomotives	Diesel electric loco
London Transport Executive	Number of vehicles in service with this type of drive : *a*) 1940 *b*) 1949 Percent. of drive in relation to : *a*) No. of motor axles, *b*) No. of motor vehicles. Total number of motor axles fitted. Maximum speed, Variation in motor speed for fixed axle speed.		
British Railways (Southern Region)	Number of vehicles in service with this type of drive. *a*) 1940 *b*) 1949 Percent. of drive in relation to : *a*) No. of motor axles, *b*) No. of motor cars. Total number of motor axles fitted. Maximum speed. Variation of motor speed with fixed axle speed.	Axle hung. Nil. 3 — — 18 106 km/h. None.	
British Railways (Eastern Region)	Number of vehicles with this type of drive : a) 1940 *b*) 1949 Percent of drive. Number of motored axles fitted. Maximum speed. Variation of motor speed.		

What is the percentage of each type of individual drive :
a) *in relation to the total number of motor axles;*
b) *in relation to the total number of motor vehicles, electric and Diesel electric.*
Total number of motor axles fitted with each of these types.
For a constant speed of rotation of the axle what are the possible maximum variations in speed of the motor?

ultiple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
Axle hung. 1 117 1 117 100 % 100 % 2 100 96 km/h None.			
Axle hung. 1049 1073 100 % 100 % 2 146 88.5 km/h None.			
Axle hung. Nil. 178 All the same. 540 112 km/h Nil.			

ADMINISTRATION		Electric locomotives		Diesel electric locom
Ceylon Government Railways	—	—		
Pennsylvania Railroad	Number of vehicles in service with this type of drive : *a*) 1940 *b*) 1949	*Frame mounted* 231 231	*Axle hung* 31 31	*Axle hung* Nil. 383
	Percent. of drive in relation to : *a*) No. of motored axles, *b*) No. of motor cars.	21 % 7 %	2 % 2 %	24 % 26 %
	Total number of motored axles fitted.	1 000	100	1 110
	Maximum speed.	160 km/h	86 km/h	160 km/h
	Variation of motor speed for fixed axle speed.	None.	None.	None.
British Railways (London Midland Region)	Number of vehicles in service with this type of drive : *a*) 1940 *b*) 1949 Percent. of drive. Total number of motor axles fitted. Maximum speed. Variation in motor speed for fixed axle speed.			
Victorian Government Railways	Number of vehicles in service with this type of drive : *a*) 1940 *b*) 1949 Maximum speed. Percent. of drive. No. of motor axles. Variation in motor speed.			

le			
Multiple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
—			
Axe hung.		Axle hung.	Axle hung.
385 385		Nil. 22	427 428
16 % 26 %		0.1 % 0.1 %	36 % 29 %
770		44	1712
122 km/h		—	102 km/h
None.		None.	None.
59 59 ly one type of drive. 236 122 km/h None.			
385 403 84 km/h y one type of drive. 1612 None.			

31. *Lateral play of the drive.*
32. *Supposing the motor axle be fixed, how many degrees, minutes and seconds, can the armature of the motor under the motor torque at the one hour rating, continuous rating at the maximum speed and at start? At w motor torque do the springs of the drive commence to flex?*

ADMINISTRATION		T	
		Electric locomotives	Diesel electric locomo
London Transport Executive	Lateral play of drive. ° Rotation at 1 h torque. Flexing torque. Weight of drive (without gears). Sprung weight. Unsprung weight, Gear ratio. Gear teeth.		
British Railways (Southern Region)	Lateral play of drive. ° Rotation at 1 h torque. Flexing torque. Weight of drive (without gears). Sprung weight. Unsprung weight. Gear ratio. Gear teeth.	4 mm None. — — — — 3.83 Straight. Satisfactory for D. C.	
British Railways (Eastern Region)	Lateral play of drive. ° Rotation at 1 h torque. Gear ratio. Gear teeth.		
Ceylon Government Railways	Lateral play of drive. Weight of drive. Gear ratio. Gear teeth.		

eight of the drive and without the train of gear wheels and pinions (if possible). Total sprung weight and
tal unsprung weight of the mechanism of the drive for each axle.
ear ratio.
ears with straight or inclined teeth (Why)?

iple unit electric motor cars		Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
mm ie. kg kg 9	*Surface* 5 mm None. — — 236 kg 244 kg 16/65			
for quieter running.				
nm — 8 mm None. — — — — 2.81 ght. Satisfactory for D. C.				
None. Rigid drive. 71 : 17. ght for simplicity.				
		— — 1 : 0.28 Straight.	— — 1 : 0.28 Straight.	

ADMINISTRATION		Electric locomotives	Diesel electric loc	
			Frame mounted	*Ax*
Pennsylvania Railroad	Lateral play of drive.	1.5 mm	1.5 mm	1
	° Rotation at 1 h torque.	None.	Not determ.	]
	Flexing torque.	—	Not determ.	
	Weight of drive (without gears).	—	1080 kg	
	Sprung weight.	Not known.	1230 kg	No
	Unsprung weight.	Not known.	None.	No
	Gear ratio.	See « Exhibit A » — Question 6.		
	Gear teeth.	Straight teeth are in general use on accou		
British Railways (London Midland Region)	Lateral play of drive.			
	° Rotation at 1 h torque.			
	Flexing torque.			
	Weight of drive (without gears).			
	Gear ratio.			
	Gear teeth.			
Victorian Government Railways	Lateral play of drive.			
	° Rotation.			
	Weight of drive.			
	Unsprung weight.			
	Sprung weight.			
	Gear ratio.			
	Gear teeth.			

ultiple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
1.5 mm		1.5 mm	1.5 mm
None.		None.	None.
—		—	—
—		—	—
Not known.		Not known.	Not known.
Not known.		Not known.	Not known.
ence of side thrust.	They also have lower first costs and maintenance costs.		
—			
—			
—			
3.76 : 1			
ht. No side thrust.			
—			
—			
—			
3170 kg			
2100 kg			
23/74			
ght teeth. As fitted in 1919.			

36. *Material of the pinions and gear wheels, chemical and physical characteristics.*

ADMINISTRATION		Electric locomotives	Diesel electric loco
London Transport Executive	Properties of material for gears.		
British Railways (Southern Region)	Properties of material for : *a)* Gears; *b)* Pinions.	Case hardened steel .61 % C. Steel. Ni — 3.48 % C — .15 % S — .26 % Mn — .53 %	
British Railways (Eastern Region)	Properties of material for : *a)* Gears; *b)* Pinions.		
Ceylon Government Railways	Gear spec.		
Pennsylvania Railroad	Properties of material for gears.	S. A. E. specification with 42) — 485 B	
British Railways (London Midland Region)	Properties of material for gears.		
Victorian Railways	Properties of material for gears.		

...e unit electric ...otor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
...ed specification ... E. 130F.			
...ardened steel ...% carbon. ...chrome steel. ...Ni. .13 % Ch.			
...ned carbon steel. ...kel steel. Brinell 500.			
	Not known.	Not known.	
available.			
...re steel. ...- 6350 kg. Tensile ...% elongation. ...hur & Ph. .05 %			

Attachment to Question 36

London Transport Executive.

The Manufacturer is required to assure himself that any Drawings or R. M. E. Specifications to which he may wish to work and which were in his possession before the receipt of the current order are the Executive's latest issues.

SPECIFICATION R. M. E. 130F for GEAR WHEELS AND PINIONS.

1. The gear wheels and pinions shall be manufactured from solid forged medium carbon steel, suitably heat treated. Alternatively, the gears shall be of the composite type consisting of a cast steel centre to B. S. S. Report No. 24, 1941, or subsequent issue, Specification No. 10, with shrunk on rim of solid forged medium carbon steel, suitably heat treated.

2. The guaranteed mechanical characteristics of the material put forward as regards the Brinell hardness of the teeth and rim after heat treatment must conform with details given below. The manufacturer must agree to replace free of charge all gears or pinions which fail through breakage or flaking at mileages under 250 000 miles if more than 5 % of the quantity supplied fail in this way at less than 150 000 miles, provided that the failure is not due to exceptional circumstances within the Executive's control.

3. The manufacturer shall, at his own cost, supply labour and appliances for all tests to be carried out at his own works.

4. The form of tooth, unless otherwise stated on the drawing, shall be in accordance with B. S. S. No. 235 and shall be straight or 7 1/2 degrees helical as indicated to the manufacturer.

5. The gears and pinions shall be finished accurately to the dimensions shown on the drawings and the teeth free from distortion.

6. Gear wheels shall be rough-bored and the bore left untreated so that it can be machined to size as required. The pinions shall be finished machined to fit the Executive's plug gauges. When required, the pinion keyways shall be cut after completion of the hardening operations.

7. Each gear and pinion shall be stamped with the manufacturer's initials and date of manufacture, and also with the Executive's Serial Number in the position shown on the drawings. The actual numbers and the position of the marking groove mentioned on the drawings will be supplied on application to the Chief Mechanical Engineer (Railways).

BRINELL AFTER TREATMENT :

Gears	550 to 600
Pinions	477 to 550

Office of the Chief Mechanical Engineer (Railways),
Acton Works, Bollo Lane, Acton, W. 3.

18th April, 1934.

Revised: 18th December, 1946.

37. *Have you locomotives with connecting rods? If so, what are the reasons which decided you to use a dividual drive?*

ADMINISTRATION			
		Electric locomotives	Diesel electric l
London Transport Executive	Preference for type of drive: a) Connecting rods. b) Motor suspension.		
British Railways (Southern Region)	Preference for type of drive: a) Connecting rods. b) Motor suspension.	None used. A nose suspended motor is satisfactory up to speeds of 121 km/h & is easy to maintain.	
British Railways (Eastern Regions)	Preference for type of drive: a) Connecting rod. b) Motor suspension.		
Ceylon Government Railways	Preference for type of drive : a) Connecting rod. b) Motor suspension.		
Pennsylvania Railroad		See Exibits « C & D ».	The type of su Individual drive
British Railways (London Midland Region)	Preference for type of drive : a) Connecting rods. b) Motor suspension.		
Victorian Government Railways	Preference for type of drive: a) Connecting rods. b) Motor suspension		

ıld you advise that the motor should be rigidly fixed to the frame and that transmission to the motor axle ıld be flexible or rather that a nose suspended motor with fixed gears is satisfactory; limit of application he two systems?

ıle unit electric ıotor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
one used. suspended motor xed gears is sim- liable and cheap, ıard on the track.			
Ɲone used. suspended motor factory up to 121 and is easy to in.			
one used. ar and nose sus- ı is satisfactory ıt least 121 km/h.			
	None used. Nose suspension satisfactory.	None used. Nose suspension satisfactory.	
endent upon the HP transmitted/axle. to connecting rods.			
Ione used. e suspended.			
Ione used. xperience with xible drive.			

Attachment to Question 37.

EXHIBIT « C »

The Pennsylvania Railroad.

There are two (2) DD1 classes of electric locomotives with connecting rods. These locomotives are included among those shown in answer to Question 6. The individual drive for electric locomotives is used for the following reasons :

1. The individual drive on the axles permits smaller motors to be located between the wheels which makes more space available in the cab for other equipment.

2. With the larger types of locomotives, the use of connecting rods would require a motor too large for a practical application, while all parts become much smaller with individual drive on the axles as well as resulting in a lower centre of gravity.

3. The absence of rods, pins and jack shaft results in lower maintenance costs with less time out of service for repairs.

Attachment to Question 38.

EXIBIT « D »

The Pennsylvania Railroad.

On our road A. C. electric locomotives, the motors are rigidly fixed to the frame using fixed gearing with flexible drive to the wheels. This application is the result of the large horse-power requirements per axle.

A nose-suspended motor with flexibility in the gearing is satisfactorily used on our lighter equipment such as A. C. switching locomotives and multiple unit passenger cars. Nose-suspended motors with fixed gearing are used with D. C. current on Diesel-electric locomotives and rail motor cars.

It is considered generally that limit of application of the two systems is based upon the horse-power requirements per axle.

39. *Effect of the passage of electric current on the running and maintenance of the parts of the drive. For ex on the bearings or springs.*
40. *Results in service of each type of drive with all the information possible concerning :*
   a) *breakage of springs;*
   b) *fracture of teeth;*

ADMINISTRATION		T	
		Electric locomotives	Diesel electric loc
London Transport Executive	Performance of drive : *a*) Effect of electric current on drive: b) Breakage of springs; *c*) Fracture of teeth; *d*) Failure rate; *e*) Measures to avoid failure; *f*) Cost of maintenance.		
British Railways (Southern Region)	Performance of drive : *a*) Effect of electric current on drive; *b*) Failures; *c*) Cost of maintenance.	No noticeable effects. Practically trouble free. Not known.	
British Railways (Eastern Region)	Performance of drive : *a*) Effect of electric current; *b*) Failures; *c*) Cost of maintenance.		
Ceylon Government Railways	Performance of drive : *a*) Effect of electric current;		
Pennsylvania Railroad	Performance of drive : *a)* Effect of electric curent; *b*) Failures.	No noticeable effect. Some use is made of earthing brushes.	No informat
British Railways (London Midland Region)	Performance of drive : *a*) Effect of electric current; *b*) Breakage of springs, etc.		
Victorian Government Railways	Performance of drive : *a*) Effect of electric current; *b*) Other failures; *c*) Cost of maintenance.		

us failures and abnormal wear;
es to which they are attributed;
ber of failures per 500 000 kilometres per axle;
sures taken to avoid or reduce their repetition;
of maintenance of each type of transmission.

ltiple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
fect due to insulated return. None used. cases due to staff negligence. 500 000 km/motored axle. are in greasing. .1/- gear/ annum.			
noticeable effects. tically trouble free. Not known.			
pitting of bearings. None. Not known.			
noticeable effect. me use is made of earthing brushes. available.			
Pitting of roller arings in axle box. information available.			
None. rox. 18 cases of broken eth in the last 5 years, all cases due to fatigue ter 1 900 000 km. Practically nil.			

41. *Supply particulars on the subject of the possible substitution of rubber suspension for metal springs.*
42. *Has one or other arrangement of drive been adopted for one of the following motives :*
a) reduction in damage to the track;

ADMINISTRATION		Type	
		Electric locomotives	Diesel electric locor
London Transport Executive	Rubber suspension.		
	Other arrangements of drive.		
British Railways (Souther Region)	Rubber suspension. Other arrangements of drive.		
British Railways (Eastern Region)	Rubber suspension. Other arrangements of drive.		
Ceylon Government Railways	Rubber suspension. Other arrangements of drive.		
Pennsylvania Railroad	Rubber suspension. Other arrangements of drive.	Not considered for suspension but is used t Drive selected by HP requirements and ease	
British Railways (London Midland Region)	Rubber suspension. Other arrangements of drive.		
Victorian Government Railways	Rubber suspension. Other arrangements of drive.		

·vement in the riding of the vehicle;
·tion in cost of maintenance of the vehicle.

·iple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
; substituted for springs where is available and the ·rature is not too None.			
·t considered. None.			
·t considered. None.			
	Not considered. None.	Not considered. None.	
nission. enance.			
information. ·rive is the most conomical.			
t considered. None.			

43. *Name of the type of bogie.*
44. *On how many vehicles is the type installed? Commencing in what year.*

ADMINISTRATION:		Typ	
		Electric locomotives	Diesel electric locor
London Transport Executive	Name of type of bogie. No. of vehicles on which bogie is installed. Commencing year. Axle arrangement. Types under construction.		
British Railways (Southern Region)	Name of type of bogie. No. of vehicles on which bogie is installed. Commencing year. Axle arrangement. Types under construction.	Three axle bogie. 3 1941 C_o — C_o None.	
British Railways (Eastern Region)	Name of type of bogie. No. of vehicles on which bogie is installed. Commencing year. Axle arrangement. Types under construction.		
Ceylon Government Railways	Name of type of bogie. No. of vehicles on which bogie is installed. Commencing year. Arrangement of axles. Types under construction.		
Pennsylvania Railroad		See attached sheet « Exhibit A » — Questio	
British Railways (London Midland Region)	Name of type of bogie. Number of vehicles on which bogie is installed. Commencing year. Axle arrangement. Types under construction.		
Victorian Government Railways	Name of type of bogie. Number of vehicles on which bogie is installed. Commencing year. Axle arrangement. Types under construction.		

angement of axles.
es under construction or in design, number of vehicles.

unit electric otor cars		Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
	Surface Welded 357 1936 A_0-1 + 1-A_0 233			
-1				
ible drive, + 2 pension (bolster- less).				
axle bogie. 1073 1915 Bo None.				
		All welded 12 1938 — None.	All welded two axle. 23 1947 — None.	
-centralising. 59 1939 B° — B° None.				
wealth cast steel e — 4 wheel. 202 1918 Axle bogie. as above.				

London Transport Executive.

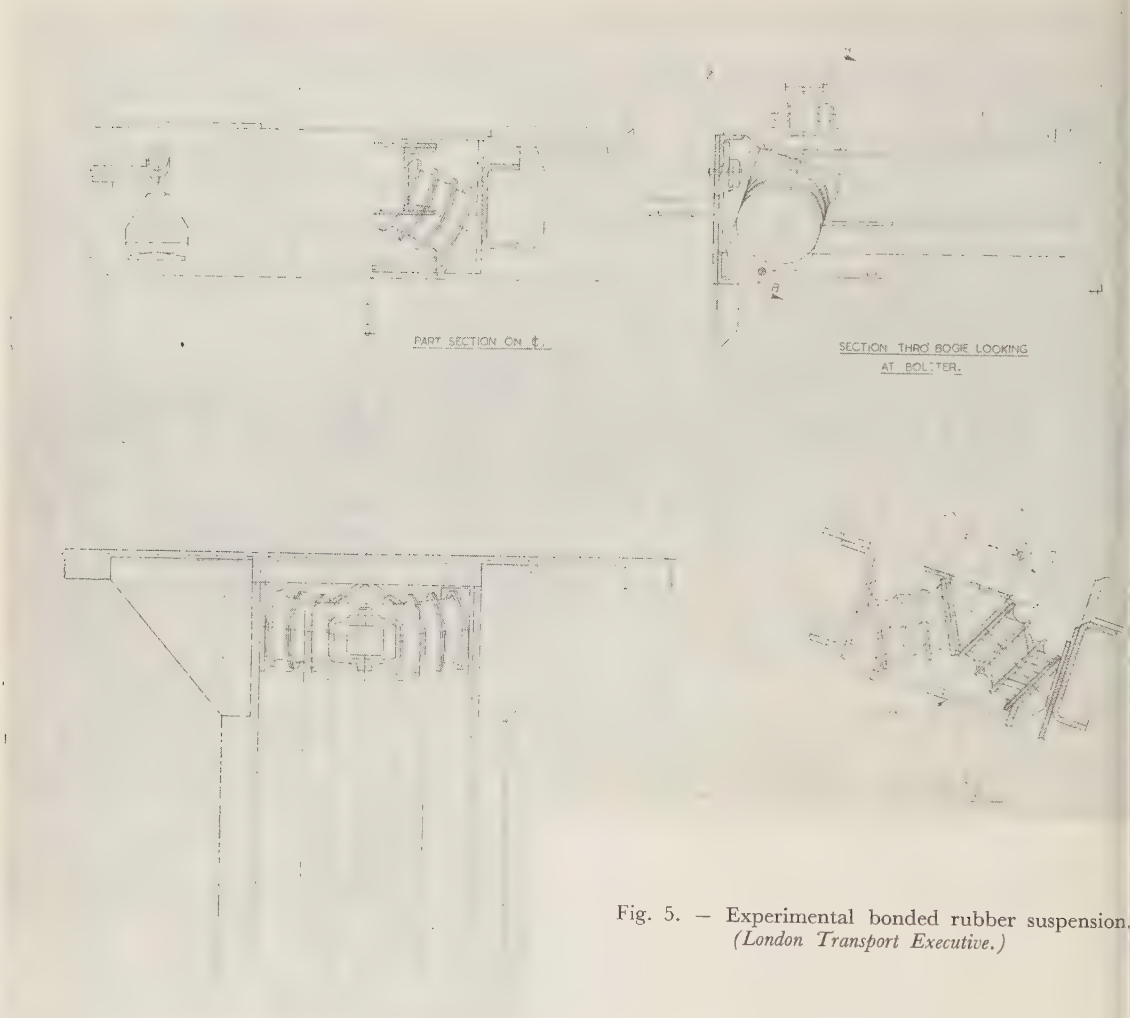


Fig. 5. — Experimental bonded rubber suspension.
(London Transport Executive.)

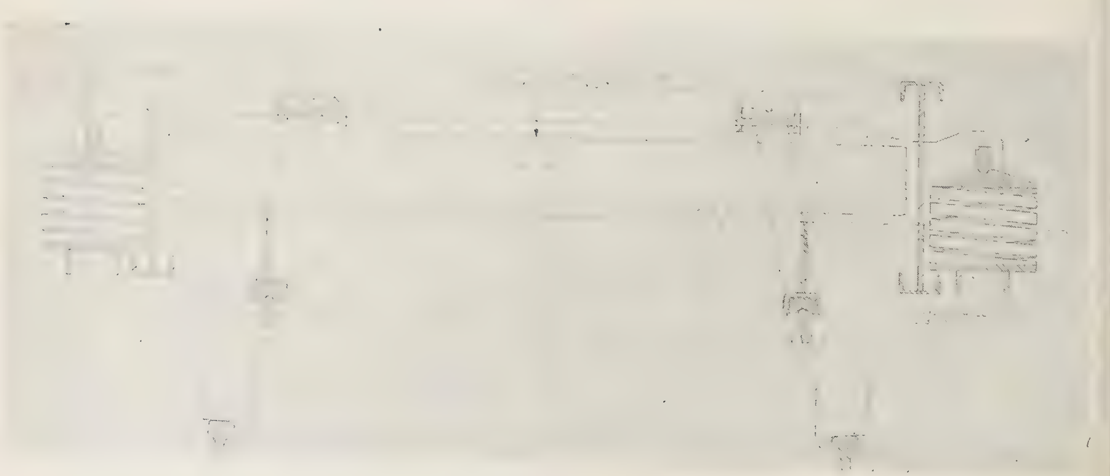


Fig. 6. — Bogie bolster knife edge suspension. « R » stock. *(London Transport Executive.)*

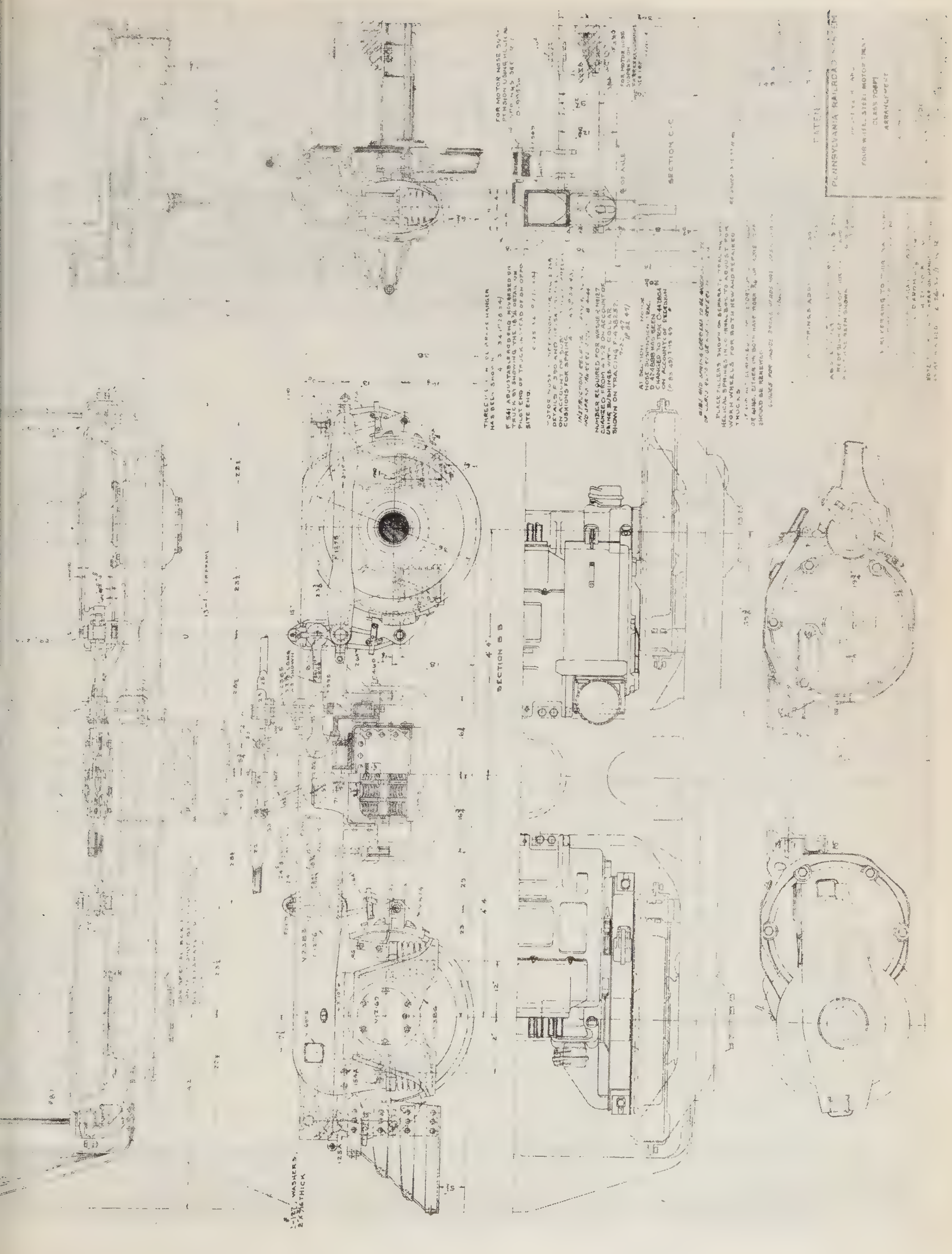


Fig. 7. — Four-wheel steel motor truck. Multiple unit electric motor cars. *(Pennsylvania Railroad.)*

47. *What is the electrical connection of the motors mounted on a bogie? Advantages or disadvantages ing from this connection?*
48. *One hour torque at maximum speed in service and for maximum tractive effort.*

ADMINISTRATION		Electric locomotives	Diesel electric locom
London Transport Executive	Electrical connections of motors. One hour torque : *a*) At maximum speed; *b*) At maximum tractive effort; *c*) At 1 hour speed.		
British Railways (Southern Region)	Electrical connections of motors. One hour torque.	Series — only possible arrangement. 126 000 kg/cm.	
British Railways (Eastern Region)			
Ceylon Government Railways	Electrical connections of motors. One hour torque.		
Pennsylvania Railroad	Electrical connections of motors. One hour torque.	See Question 6. — The disadvantage of n Not determined.	
British Railways (London Midland Region)	Electrical connections of motors. One hour torque.		
Victorian Government Railways	Electrical connections of motors. One hour torque : *a*) At maximum speed; *b*) At max. tractive effort; *c*) At one hour speed.		

ple unit electric motor cars		Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
- l.	*Surface* Parallel.			
g/cm	1 640 kg/cm			
g/cm g/cm	21 850 kg/cm 15 200 kg/cm			
ries-Parallel. 000 kg/cm				
		Series-Parallel.	Series-Parallel.	
ie unbalanced voltage under conditions of wheel slip.				
ries-Parallel. t available.				
nanent series. 490 kg/cm 000 kg/cm 000 kg/cm				

49. *Particulars of the maintenance work and frequency.*

ADMINISTRATION		T	
		Electric locomotives	Diesel electric loco
London Transport Executive	Examination. Inspection Overhaul. Lubrication.		
British Railways (Southern Region)	Overhaul.	Renewal of worn parts 160 900 km.	
British Railways (Eastern Region)			
Ceylon Government Railways	Inspection. Overhaul.		
Pennsylvania Railroad	Examination. Inspection. Overhaul.	Daily. 4 weekly. 602 500 to 724 000 km as required.	Daily. 4 weekl 1 609 000 k
British Railways (London Midland Region)	Examination. Inspection. Overhaul.		
Victorian Government Railways	Overhaul.		

cle			
ltiple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
3 daily. 4 weekly. ars or 320 000 km ushes etc. 8 weekly. bearers 12 weekly.			
wal of worn parts 160 900 km.			
	Weekly. 1 500 hours.	Weekly. 1 500 hours.	
Daily. 8 000 km. 4 years.		Daily. 80 000 km. 245 000 km.	Daily. 4 weekly. Yearly.
Daily. ly. Truck lubrication. ly. Drive lubrication. ly. Axle bg. lubricat. days and 4 years.			
121 000 km. 240 500 km.			

50. *Horizontal forces on the rail due to the bogie*
51. *Transverse play of the axle in relation to the bogie.*
52. *Angular play in the horizontal plane of the axles in relation to the bogie.*

ADMINISTRATION		Electric locomotives	Diesel electric locor
London Transport Executive	Horizontal force on rail : *a)* Acceleration; *b)* Braking. Transverse play of axle. Horizontal angular play of axles.		
British Railways (Southern Region)	Horizontal force on rail. Transverse play of axle. Horizontal angular play of axles.	Not known.	
British Railways (Eastern Region)			
Ceylon Government Railways	Transverse play of axles.		
Pennsylvania Railroad	Horizontal force on rail. Transverse play of axle. Angular play in horizontal plane of axles.	See « Exhibit E ». Norm. 9 mm.Max. 18 mm.	Norm. 9 mm. Max.
British Railways (London Midland Region)	Horizontal force on rail. Transverse play of axle. Horizontal angular play.		
Victorian Government Railways	Horizontal force on rail. Transverse play of axle.		

The Penns

In order to have equilibrium of the vehicle on the rail, the height of its centre o rail should have the trucks designed on the basis of the horizontal force at the r inches the horizontal force at the rail would be about 41 % of the weight at rai

iple unit electric motor cars		Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
ɛ	*Surface*			
kg	1 930 kg			
kg	3 130 kg			
mm. Max. 9 mm.				
ᴵᵒ 16′ max.				
Not known. mm. Max. 6.35 mm				
		About 3 mm.	About 3 mm.	
mm. Max. 18 mm.			Norm. 9 mm. Max. 18 mm.	Norm. 9 mm. Max. 18 mm.
.3 mm. Max. 7 mm.				
6.3 mm (Total).				

Attachment to Question 50.
EXIBIT « E »

d.

rail must be considered. A vehicle with a centre of gravity of 52 inches above % of the total weight on truck at rail. With a vehicle centre of gravity of 72

53. *For what reasons do you not use more of certain types of bogie and which types?*
54. *Results obtained with these bogies (maintenance, purchase price, behaviour, etc.).*

ADMINISTRATION		Electric locomotives	Diesel electric loco
London Transport Executive	Maintenance. Purchase price of : *a*) Tube; *b*) Surface.		
British Railways (Southern Region)	Maintenance. Price	Good. Low maintenance cost. —	
British Railways (Eastern Region)			
Ceylon Government Railways			
Pennsylvania Railroad	Preferred type of bogie. Maintenance. Cost.	Pedestal type swing bolster type is used as it is The present bogies with cast steel sole pla	
British Railways (London Midland Region)	Maintenance. Purchase price.		
Victorian Government Railways	Maintenance. Cost.		

iple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
ıance is simplified ıse of individual cylinders and a er design. 400 — 1938 360 — 1938			
Low maintenance cost. —			
actory from the point of view of riding qualities. ceable axle box liners result in low maintenance costs. — —			
plate frame type oned as fatigue s developed. l sided type aban-d in favour of cast type for ease of ıfacture. —			

55. *What is your experience of the riding of the motor vehicles in service (as it concerns the constructio[n] bogies). Does your reply on the subject take account of the point of view of the Permanent Way Depar[tment]*

ADMINISTRATION		Electric locomotives	Diesel electric loc[omotives]
London Transport Executive	a) C. M. E. Dept. b) P. W. Dept.		
British Railways (Southern Region)	a) C. M. E. Dept. b) P. W. Dept.	Satisfied. No adverse comments. Riding superior to multiple unit motor cars.	
British Railways (Eastern Region)			
Ceylon Government Railways			
Pennsylvania Railroad	a) C. M. E. Dept. b) P. W. Dept.	Riding properties of the pedestal type swing-b[olster]	
British Railways (London Midland Region)	a) C. M. E. Dept. b) P. W. Dept.		
Victorian Government Railways	a) C. M. E. Dept. b) P. W. Dept.		

*ıot, what is the point of view of the Permanent Way Department? What is that of the Motive-Power De-
tment?*

ple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
have longer side s than previous These increase otion of road shock. s the maximum le distance be- bolster side- s, giving increased ability. wheel base bogie sidered to be more to « hunting ». fect on riding rt of track wear is uated by small s, short wheel base, ng weight, lateral nd loss of coning eels.			
Satisfied. considered that g and oscillation nore marked on c as compared steam stock. nt shock is accent- by unsprung t.			
	Satisfactory.	Satisfactory.	
are considered to be the most satisfactory.			
y satisfactory. —			
ked difference be- different types is able. It is consi- that the channel bogie gives the y smoother ride.			

57. *What is the effect of the diameter of the wheels on the deterioration of the track at high speeds?*
58. *Have you a rule on your system which fixes the diameter of the wheels in relation to the speed or weigh axle or limits one or the other of these factors in relation to the other?*

(See also Question 22.)

ADMINISTRATION		Ty Electric locomotives	Diesel electric loc
London Transport Executive	Effect of wheel diameter on track. Determination of wheel diameter.		
British Railways (Southern Region)	Effect of wheel diameter.	For speeds up to 75 mph if	$\frac{\text{static wheel loa}}{\text{wheel diameter}}$
British Railways (Eastern Region)			
Ceylon Government Railways	Determination of wheel diameter.		
Pennsylvania Railroad	Effect of wheel diameter on track. Determination of wheel diameter.	Not determined. Class « A » wheels.	650 lbs./inch Class « C »
British Railways (London Midland Region)	Effect of wheel diameter. Determination of wheel diameter.		
Victorian Government Railways	Effect of wheel diameter. Determination of wheel diameter.		

e			
ple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
See Q. 21. Empirical.			
20 shearing of the rail head may occur.			
	Empirical.	Empirical.	
% Class « B » wheels 750 lbs./inch dia. C = .57 — .67 %. bs/inch. dia. C = .67 — .77 %. C = Carbon content.			A.A.R. Spec. M-107-48.
— —			
— Empirical.			

59. *Have you yet made tests of the stability of the vehicles while running and measured the forces betwee rail? What are the results of these tests? Methods of measuring.*
60. *Can you give sources of data concerning theoretical calculations of the forces between rail and wheel or add such calculations or results of tests to your reply?*
61. *What is the trend of your ideas for the future.*

ADMINISTRATION		Electric locomotives	Diesel electric loc
London Transport Executive	Tests of stability and forces between wheel and rail. Trend of future ideas		
British Railways (Southern Region)	Tests of stability and forces between wheel and rail. Trend of future ideas. Tests.	None. Similar. None.	
British Railways (Eastern Region)			
Ceylon Government Railways			
Pennsylvania Railroad	Tests. Trend of future ideas.	See Q. 22. Present designs are satisfactory.	
British Railways (London Midland Region)	Tests. Future ideas.		
Victorian Government Railways	Tests. Future ideas.		

Questions 59 and 60. — See Appendix to Question 22.

ple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
None. See Q. 22. ional types im- d in direction of maintenance costs nger periods with- ndue wear.			
None. ental radial bear- gie. R.) Dynamic load 1. U. motor bogie out 10 % higher steam loco.			
None. —			
None. vania) Common- cast steel frame heel bogie.			

62. *Have you any special remarks to make?* — No special remarks.
63. *Would you prefer from the point of view of bogie construction and of its maintenance to have inside or axle boxes? Why?*
64. *Do you consider that the motor should be placed as low as possible or above the level of the motor axl*

ADMINISTRATION		Electric locomotives	Diesel electric loco
London Transport Executive	Axle boxes. Motor position.		
British Railways (Southern Region)	Axle boxes. Motor position.		
British Railways (Eastern Region)			
Ceylon Government Railways	Axle boxes. Motor position.		
Pennsylvania Railroad	Axle boxes. Motor position.	Outside boxes are preferred, as they allow At axle level.	
British Railways (London Midland Region)	Axle boxes. Motor position.		
Victorian Government Railways	Axle boxes. Motor position.		

ple unit electric notor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
boxes are pre- for ease of access ace for motors. bogies are used is no space for above axle.			
itside boxes are e with axle hung . w as possible.			
Outside. w as possible.			
or the motors and drive. Outside boxes are also easier to maintain.			
le for ease of aintenance.			
boxes. Only pos- rrangement with ng motors. own. Present ar- nent has motors at vel.			

65. *Number of vehicles using this type of bogie?*
66. *Types of motor bogie.*
67. *Number of non-motored and motored axles of a bogie.*
68. *Diameters of the wheels.*

ADMINISTRATION		Ty	
		Electric locomotives	Diesel electric loc
London Transport Executive	Number of vehicles using bogie. No. of types of motor bogie. Axle arrangement. Wheel diameter. Maximum weight/axle. Axle spacing. Distance between centre plates.		
British Railways (Southern Region)	No. of vehicles using bogie. Types of motor bogie. Axle arrangement. Wheel diameter. Maximum weight/axle. Axle spacing. Distance between centre plates.	3 One. C_0 1.13 m. 18 420 kg. 2 345 m. 8.68 m.	
British Railways (Eastern Region)	No. of vehicles using bogie. Types of motor bogie. Axle arrangement. Wheel diameter. Maximum weight/axle. Axle spacing. Distance between centre plates.		

er axle.
of axles.
between bogie centre plates.

	ɔle unit electric ıotor cars		Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
		Surface			
		357			
		2			
	$_0$-1	A_0-1+1-A_0			
	.	.915 m.			
	g.	11 850 kg.			
	.	2.38 m.			
	tr.)	(Asymmetr.)			
	ı.	10.1 m.			
	1073				
	—				
	B_0				
	1.13 M.				
	3 863 kg.				
	! 667 M.				
	—				

ADMINISTRATION		Typ	
		Electric locomotives	Diesel electric loco
Ceylon Government Railways	No. of vehicles using bogie. Types of motor bogie. Axle arragement. Wheel diameter Maximum weight/axle. Axle spacing. Distance between centre plates.		
Pennsylvania Railroad	No. of vehicles using bogie. Types of motor bogie. Axle arrangement. Wheel diameter. Maximum weight/axle. Axle spacing. Distance beween centre plates.	See question 6.	
British Railways (London Midland Region)	No. of vehicles using bogie. No. of types of motor Bogie Axle arrangement. Wheel diameter. Maximum weight axle. Axle spacing. Distance between centre plates.		
Victorian Government Railways	Number of vehicles using bogie. Types of motor bogie. Axle arrangement. Wheel diameter. Maximum weight/axle. Axle spacing. Distance between centre plates.		

ple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
	— One. Bo .865 m. 13 300 kg. 2.44 m. —	23 One. Bo .865 m. 10 280 kg. 2.44 m. —	
59 1 Bo .915 m. 3 750 kg. 2.58 m. 14.9 m.			
202 3 Bo 1.07 m. 2 900 kg. 2.58 m. 12.6 m.			

72. *With or without a centering device.*
73. *With or without swing or other bolster.*
74. *With or without an anti-nosing arrangement.*
75. *With or without an anti-weight transfer device.*

ADMINISTRATION			
		Electric locomotives	Diesel electric locc
London Transport Executive	Centering device. Swing or other bolster. Anti-nosing device. Anti-weight transfer device. Lateral coupling of bogies. Shock absorbers : *a*) Vertical; *b*) Longitudinal; *c*) Transverse.		
British Railways (Southern Region)	Centering device. Swing or other bolster. Anti-nosing device. Anti-weight transfer device. Lateral coupling of bogies. Shock absorbers : *a*) Vertical; *b*) Longitudinal *c*) Transverse.	With. Without. Centering device. Without. Without. None.	
British Railways (Eastern Region)	Centering device. Swing or other bolster. Anti-nosing device. Anti-weight transfer device. Lateral coupling of bogies. Shock absorbers : *a*) Vertical; *b*) Longitudinal; *c*) Transverse.		
Ceylon Government Railways	Centering device. Swing or other bolster.		

h or without coupling of bogies in the lateral plane.
h or without shock absorbers (or rebound dampers) for vertical movements.
h or without shock absorbers (or rebound dampers) for longitudinal movements.
h or without shock absorbers (or rebound dampers) for tranverse movements.

cle			
Multiple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
Without. Swing bolster. Without. Without. Without. None.			
Without. Swing bolster. Without. Without. Without. None.			
	Without. Swing bolster.	— —	

ADMINISTRATION		Typ	
		Electric locomotives	Diesel Electric locomoti
Penysylvania Railroad	Centering device. Swing or other bolster. Anti-nosing device. Anti-weight transfer device. Lateral coupling of bogies. Shock absorbers : *a*) Vertical; *b*) Longitudinal; *c*) Transverse.	Only on 2 & 4 wheel bogies. Swing bolster. Without. Without. Only class GGI 44 (locos) None.	Without. Swing bolster. Without. Without. Only class BP1 (12 loc
British Railways (London Midland Region)	Centering device. Swing or other bolster. Anti-nosing device. Anti-weight transfer device. Lateral coupling of bogies. Shock absorbers : *a*) Vertical; *b*) Longitudinal; *c*) Transverse.		
Victorian Government Railways	Centering device. Swing or other bolster. Anti-nosing device. Anti-weight transfer device. Lateral coupling of bogies. Shock absorbers : *a*) Vertical; *b*) Longitudinal; *c*) Transverse.		

...le unit electric ...motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
Without. ...ing bolster. Without. Without. Without.		Without. Swing bolster. Without. Without. Without.	Without. Cast integ. with track frame. Without. Without. Without.
None.		None.	None.
Without. ...ing bolster. With. Without. Without.			
Without.			
Without. ...ing bolster. Without. Without. Without.			
Without.			

78. *Construction of the frame (plate, rolled sections, box cast or other).*
79. *Best angle for the transverse suspension links of the bolster for each type of bogie.*
80. *Means of restriction of and lateral movement permitted between the body and the bogie.*

ADMINISTRATION		Electric locomotives	Diesel electric loco[motives]
London Transport Executive	Construction of bogie. Best angle for bolster links. Method of restraining lateral movement. Suspension of body. Support of body on bogie. Axle boxes.		
British Railways (Southern Region)	Construction of bogie. Best angle for bolster links. Method of restraining lateral movement. Suspension of body. Support of body on bogie. Axle boxes.	Plate sections with stiffener welded along top. No bolster. Segmental bearings. Segmental bearings. Segmental bearings. Plain white metal.	
British Railways (Eastern Region)			
Ceylon Government Railways	Construction of bogie. Best angle for swing links. Method of restraining lateral movement. Suspension of body. Support of body on bogie. Axle boxes.		

Suspension of the body on the bogie (connection).
Type of support of the body on the bogie.
Axle boxes (roller, plain bearing).

icle			
Multiple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rails cars	Diesel electric shunters
Welded plate. in 6 (dependent upon track). Centre bearing. King Pin. olster with coil springs and Swing links. Roller.			
Built up of plate and rolled sections. 1 in 7. top brackets fitted to nds of bolster & bogie. side plates. 38 mm. swing allowed (Total). King Pin. Centre casting. Plain white metal			
	All welded plate. — Centre bearing. King Pin. Bolster side bearings. Roller.	All welded plate. — Centre bearing. King Pin. Bolster side bearings. Roller.	

ADMINISTRATION		Type	
		Electric locomotives	Diesel electric locomotive
Pennsylvania Railroad	Construction of bogie. Best angle for bolster links. Method restraining lateral movement. Suspension of body. Support of body on bogie. Axle boxes.	Box cast steel. 1 in 8 Centre bearing. Centre bearing and King Pin. Centre plate. Roller on all modern types.	Box cast steel. 1 in 8 Centre bearing. Centre bearing and Kin Pin. Centre plate. Roller.
British Railways (London Midland Region)	Construction of bogie. Best angle for links. Method of restraining lateral movement. Suspension of body. Support of body on bogie. Axle boxes.		
Victorian Government Railways	Construction of bogie. Best angle for links. Method of restraining lateral movement. Suspension of body. Support of body on bogie. Axle boxes.		

tiple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
Rolled steel. 1 in 8. 'entre bearing. bearing and King Pin. Centre plate. ain and roller.		Box cast steel. 1 in 8. Centre bearing. Centre bearing and King Pin. Centre plate. Roller.	Box cast steel. — Centre bearing. Centre bearing and King Pin. Centre plate. Plain and roller.
:lded. H. T. steel. — King Pin. entre bearing. entre bearing. ıppered roller.			
e (2) Rolled section 3ox cast steel. 1 in 7 1/2 3olster stops. :entre plate with gie centre pin. pring bolster. 'lain bearing.			

84. a) *What is the material used for the axle?*
b) *What is the interference on the axle seats?*

ADMINISTRATION		Electric locomotives	Diesel electric locor
London Transport Executive	Axle material. Interference : *a*) Wheels and gears; *b*) Roller bearing race. Cause of fractures.		
British Railways (Southern Region)	Axle material. Interference. Cause of fracture.	Steel forgings. .008″ total. No.	
British Railways (Eastern Region)			
Ceylon Government Railways	Axle material. Interference. Cause of fracture.		
Pennsylvania Railroad	Axle material. Interference. Cause of fractures.	A. A. R. Specification M — 126 — 49, C Interference is governed by material of whe Dia. of wheel seat 5 1/4″ — 6″ 6″ — 6 5/8″ 6 5/8″ — 7 1/4″ 7 1/4″ — 7 7/8″ More than 7 7/8″ To achieve these tonnages the following interef Dia. of wheel seat 5″ — 6″ 6″ — 8″ 8″ — 10″ Axle and wheel fractures can generally be att	
British Railways (London Midland Region)	Axle material. Interference. Cause of fracture.		
Victorian Government Railways	Axle material. Interference. Cause of fracture.		

Have you had axle or wheel fractures due to the drive or to the factors a) *or* b) *above?*

ple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
M.E.7J (attached). n dia + .001 ± .001 0015″ Total. Not known.			
. 3 1928 Report 24 012″ Total. No.			
	BSS. No. 3 Report 24 — No.	BSS. No. 3 Report 24 — No.	
nd finish of surfaces in contact. Steel wheels 55 — 75 ton. 70 — 90 ton. 75 — 100 ton. 80 — 110 ton. 85 — 120 ton. lly apply. Interference .010″ — .0120″ .0120″ — .0140″ .0140″ — .0160″ ty material.		Nominal interference. /inch seat dia. = .002″	
ality acid or basic steel. Ph. or S .06 % — No.			
40 ton Tensile) .018″ based on on/inch seat dia. No.			

Attachment to Question 84.

London Transport Executive.

The manufacturer is required to assure himself that any drawings or R. M. E. Specifications to which he may wish to work and which were in his possession before the receipt of the current order are the London Transport Executive's latest issues.

SPECIFICATION R.M.E. 7J
for
MOTOR, MOTOR TRAILER AND TRAILER AXLES

1. *Scope.*

This specification covers motor, motor trailer and trailer axles, completely-finished or with rough-turned gear wheel and road wheel seats, as stated on the order.

2. *Material.*

The material shall be in accordance with British Standard Specification Report No. 24-1941 or subsequent issue, Specification No. 2.

3. *Forging size.*

Axles shall be forged of such a size that a minimum of 3/32-inch of metal shall be removed from every part of the surface during the machining of the axles.

4. *Marking (hot).*

Each axle, when hot, shall be distinctly stamped on the ends (not the body) with the particulars shown on drawing No. 32999A, care being taken that the stamping is of such depth as to be completely machined off before polishing.

5. *Heat treatment.*

All axles shall be oil-hardened and tempered. Axles heat-treated by normalising will not be acceptable.

The manufacturer, on acceptance of the order, shall advise the chief mechanical engineer (Railways) in writing, of the ranges of temperature between which the axles would be hardened and tempered.

The manufacturer shall afford necessary facilities for the representative of the chief mechanical engineer (Railways) to examine pyrometer records of the heat treatment furnaces to satisfy himself that the heat treatment proposed by the manufacturer has been performed on the whole of the axles ordered.

6. *Discs for information purposes only.*

From the axles selected by the representative of the chief mechanical engineer (Railways) in accordance with clause 6 of the British Standard Specification Report No. 24—1941 or subsequent issue, Specification No. 2, the manufacturer shall, after completion of the tests described in clauses 7 and 8, or 8 and 9 as the case may be, machine cold from such axles a disc approximately 3/8-inch thick having the same diameter as the forged wheel

seat or forged journal and portion of the axle. In the case of axles forged with a prolongation, this disc shall be taken as near as possible to the journal end of the axle. The disc, marked with particulars of Cast Number and Order Number, shall be forwarded to the chief mechanical engineer (Railways) with the test report.

7. *Tests in case of departure from heat treatment procedure.*

In cases where variation from the heat treatment proposed by the manufacturer occurs, axles at the rate of one axle for each 55 axles or portion thereof of the axles concerned shall be selected by the representative of the chief mechanical engineer (Railways) and stamped circumferentially on the road wheel seat or prolongation of the axle/s.

The manufacturer shall machine cold from each axle stamped as above, a test piece 3/8-inch thick, having the same diameter as the forged wheel seat, or prolongation, as the case might be, and including the brands.

Without further heat treatment or manipulation, the test pieces shall be placed at the disposal of the chief mechanical engineer (Railways) who will arrange for them to be subjected to a miscroscopic test. Alternatively, the manufacturer may prepare a photomicrograph (100 diameters) of the transverse face of the test piece and submit duplicate copies to the chief mechanical engineer (Railways), together with one half of test piece. The position on the transverse face of the test disc at which the photomicrograph is taken shall be indicated and shall be within 1 1/2 inches from the surface of the heat-treated axle.

The microscopic structure shall be subject to the approval, in writing, of the chief mechanical engineer (Railways).

Should the result of the microscopic test be approved, the individual or group of axles represented by the test piece shall be accepted, provided that the axles in all other respects conform to the requirements of British Standard Specification Report No. 24—1941 or subsequent issue, Specification No. 2.

In the event of the individual or group of axles represented by the test piece failing to meet the requirements of the microscopic test, the axles represented shall be re-heat-treated and re-submitted for test and acceptance or otherwise.

8. *Finish.*

All axles shall be machined or ground all over (except gear wheel and road wheel seats where required rough-turned) to a smooth finish showing no tool marks, and shall have centres drilled and countersunk with a taper of 60°. All journals and (except for collared axles) ends shall be polished. The fillet radius, shown on the drawing, between wheel seats and body of axle shall join the latter without step or line demarcation.

9. *Dimensions.*

The middles (except at gear wheel seats or suspension bearing journals) shall be machined or ground to diameters within the limits shown on the drawings.

Overall length shall not vary by more than 0.02 inch above or below the figured dimension for any axle.

Diameters at axle box and suspension bearing journals shall be within the limits figured on the drawings.

The length of journals and the distance between them, centre to centre, and between collars shall not be more than 0.02 inch above or below the figured dimensions.

The diameter of finished seats for wheels and gear wheels shall be within the limits figured on the drawings.

When axles with rough-turned wheel or gear wheel seats are specified, the diameter of the wheel seat shall be left 1/8-inch over the nominal size for the finished seat as shown on the appropriate drawing. All other parts shall be finished and polished as required herein for finished axles.

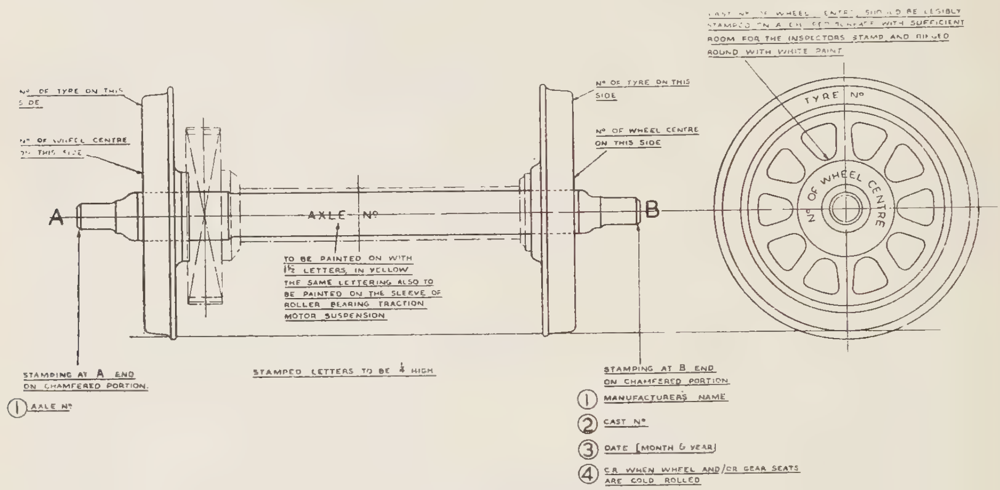


Fig. 8.

10. *Marking of finished axles.*

The marking (Clause 4) shall be re-stamped cold on the chamfered portions at the ends of the journals after machining.

11. *Protection.*

The finished portions of axles shall be coated with white lead and tallow or other approved coating medium after being machined, and all journals and finished wheel or gear wheel seats securely protected from damage in transit.

Office of the chief mechanical engineer (Railways, Acton works, Bollo lane, Acton W. 3.

Revised March, 1931.

Revised March, 1937.

Revised September, 1938.

Revised February, 1945.

Revised February, 1947.

Revised 2nd April, 1947.

Revised January, 1948.

85. *What is the method of suspension of the bogie frame on the wheels?*
86. *What are the characteristics, the deflection in cm/t (tonne) and the maximum deflection of the*
laminated springs;
volute springs;

ADMINISTRATION		Electric locomotives	Diesel electric loco
London Transport Executive	Suspension of bogie frame on wheels. Axle boxes.		
British Railways (Southern Region)	Suspension of bogie frame on wheels. Axle boxes.	Laminated side springs + auxiliary coil springs. Plain white metal boxes with straight guides. Lubrication pad under journal.	
British Railways (Eastern Region)			
Ceylon Government Railways	Suspension of bogie frame on wheels. Axle boxes.		
Pennsylvania Railroad		See attached.	
British Railways (London Midland Region)	Suspension of bogie frame on wheels. Axle boxes.		
Victorian Government Railways	Suspension of bogie frame on wheels. Axle boxes.		

l springs;
ber blocks;
ck absorbers (or rebound dampers).
pe of axle boxes and type of guides.

ple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
/ coil springs + ated side springs. roller bearings oxes with mangane- l horn guides.			
ed side bearing s. 1/2″ plain bearing with straight gui- il waste lubrication.			
	Laminated side springs + auxiliary coil springs. Roller bearing boxes with manganese steel liners.	Laminated side springs + auxiliary coil springs. Roller bearing boxes with manganese steel liners.	
ed side springs. in cast steel Guides of cast iron nganese steel.			
l spring beam. r with coil springs. ce cast steel with bearing. vaste lubrication. iides of hardened			

Attachment to Questions 85, 86 and 87
EXHIBIT « G »

The Pennsylvania Railroad.

Electric locomotives.

Truck frame is supported on a semi-elliptical spring on each pedestal type journal box; the inside ends of the springs carry equaliser bars which support the frame at the transverse centreline of the truck and the outside ends of the springs carry hangers with helical springs which support the frame at the ends.

The spring rate per truck side for the group is G. 54 cm/Tonne (.296 cm/Tonne for helical and .242 cm/Tonne in. for elliptical.)

Diesel-electric locomotives.

Truck frame is supported on helical springs on equaliser bars supported on pedestal type journal boxes. Springs consist of 2 elliptical (2-unit) springs at bolster and 4 helical springs on equaliser bars per truck side.

Spring rates per truck side :

Bolster group	.28 cm/Tonne.
Equaliser	.145 cm/Tonne.

Multiple unit cars.

Truck frame supported on helical springs on wing type journal boxes. Springs consist of one elliptical (5-unit) spring at bolster and four helical springs on wing type boxes per truck side.

Spring rates per truck side :

Bolster springs	.675 em/Tonne.
Journal box springs	.205 cm/Tonne.

New multiple unit cars.

Truck frame supported on helical springs on equaliser bars supported on pedestal type journal boxes. Springs consist of four helical and one elliptical (single unit) at bolster and four helical at equaliser per truck side.

Spring rates per truck side :

Bolster group	1 .375 cm/Tonne.
Equaliser group	.435 cm/Tonne.

Diesel-electric rail cars.

Truck frame is supported on helical springs on equaliser bars supported by pedestal type journal boxes. Springs consist of one elliptical (3-unit) at bolster and two helical at equaliser per truck side.

Spring rate per truck side :

Bolster springs	.415 cm/Tonne.
Equaliser springs.	.256 cm/Tonne.

The above springs are the only types of cushioning means generally used on the trucks under the equipment being considered.

British Railways (Southern Region).

Electric locos.

Laminated side springs.

(*a*) 1 372 mm centres. 13 plates, 152 mm wide × 10.54 mm thick, and 1 plate 152 mm wide × 9.5 mm thick.
(*b*) Deflection — 1.23 cm/tonne.
(*c*) Total deflection — 9.2 cm.

Electric motor cars.

Laminated side springs.

(*a*) 1 372 mm centres. 9 plates, 102 mm wide × 15.87 mm thick.
(*b*) Camber free 85.52 mm, 6.35 mm camber at 5.9 tonnes.
(*c*) Deflection — 1.06 cm/tonne.

London Transport Executive.

Multiple unit motor cars.

Multiple unit motor cars	1938 Tube		« O » & « P » Surface	
	Cm/Tonne	Max. Cm	Cm/Tonne	Max. Cm
Bolster.				
Coil	1.13	7.31	0.665	4.54
Side springs.				
Main laminated M. A.	1.36	8.74	1.715	11.01
Auxiliary coil M. A.	1.015		0.846	
Main laminated N. M. A.	1.68	8.76	2.07	9.78
Auxiliary coil N. M. A.	1.38		0.846	

M. A. = Motored axle.
N. M. A. = Non-motored axle.

Note. — For tube stock auxiliary coil spring deflections are given as an average, laminated springs being also asymmetric, requiring different auxiliary coil springs at each position.

Ceylon Government Railways.

Diesel-electric motor cars.

	Deflection.
Motor bogie laminated springs	.68 cm/t
Motor bogie auxiliary coil springs	.565 cm/t
Articulated bogie laminated springs	1.02 cm/t
Articulated bogie auxiliary coil springs	1.02 cm/t

Diesel-electric rail cars.	*Deflection.*
Motor bogie laminated springs	1.36 cm/t
Motor bogie auxiliary coil springs	.98 cm/t
Trailing bogie laminated spring	1.13 cm/t
Trailing bogie auxiliary coil spring	.46 cm/t

British Railways (Midland Region).

Electric motor cars.

(a) *Laminated side springs.*

Centres of suspension bolts	1 375 mm
Deflection of one spring	1 282 cm/t
Maximum movement from « tare » position	4 cm

(b) *Bolster springs.*

Two concentric « Timmis » section springs/nest.

Deflection of one nest	877 cm/t
Maximum movement from « tare » position	3.2 cm.

Victorian Government Railways.

Multiple unit electric motor cars.

Laminated springs.

Full elliptic (4 per nest), 9 plates 7.6 cm × .95 cm, length 89 cm unloaded.
Maximum deflection : 9.95 cm.

Coil springs.

	Outer	*Inner*
Outside diameter	22.9 cm	14.6 cm
Diameter of bar	3.8 cm	2.54 cm
Free height	33.8 cm	33.6 cm
Active coils	12.1 cm	19.1 cm
Deflection	1.675 cm/tonne	3.425 cm/tonne
Maximum deflection	6.655 cm	6.502 cm

88. *Initial play between the guides and the axle boxes.*
89. *Maximum play between the guides and the axle boxes.*
90. *Initial lateral play of the motor axles (mm).*

ADMINISTRATION		Electric locomotives	Diesel electric loc
London Transport Executive	Axlebox play : *a*) initially; *b*) maximum. Lateral play of axle : *a*) initially; *b*) maximum. Flexible connections.		
British Railways (Southern Region)	Axlebox play : *a*) initially; *b*) maximum. Lateral play of axle : *a*) initially; *b*) maximum. Flexible connections.	 .076 mm .5 mm 1st & 3rd axle. Middle 1.58 mm 20 mm 4.75 mm 25.4 mm Not used.	
British Railways (Eastern Region)			
Ceylon Government Railways	Axlebox play : *a*) initially. Flexible connections.		
Pennsylvania Railroad	Axlebox play : *a*) initially; *b*) maximum. Lateral play of axle : *a*) initially; *b*) maximum. Flexible connections.	 1.5 mm 3.0 mm on high 9 mm (total) 18 mm Not used.	 1.5 mm speed trucks. 9 mm 18 mm Not use
British Railways (London Midland Region)	Axlebox play : *a*) initially; *b*) maximum. Lateral play of axle : *a*) initially : *b*) maximum. Flexible connections.		
Victorian Government Railways	Axlebox play : *a*) initially; *b*) maximum. Lateral play of axle : *a*) initially; *b*) maximum. Flexible connections.		

91. *Maximum lateral play of the motor axles (mm).*
92. *Do you use a flexible connection between the axles and the axle boxes or between the bearings and the axle boxes? If so, would you give particulars from the point of view of the elasticity as well as a concise description.*

icle			
Multiple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
1.5 mm. 5.5 mm. 2.3 mm. 8.7 mm possible 4.7 mm normally. Not used.			
1.59 mm. 3.18 mm. 3.18 mm. 6.36 mm. Not used.			
	3.0 mm. Not used.	3.0 mm. Not used.	
1.5 mm. 4.5 mm on moderate speed trucks. 9 mm. 18 mm. Not used.		1.5 mm. 9 mm. 18 mm. Not used.	1.5 mm. 9 mm. 18 mm. Not used.
6.35 mm. 10.00 mm (approx.) About 3 mm. Hardly any wear. Not used.			
1.5 mm (total) 3.0 mm (total) 6.0 mm (total) 12.0 mm (total) Not used.			

93. *Effect of the play of the axles on good riding.*
94. *Possible effect of the intermediate and rear axles on the axle ahead r om the point of view of the force rail and wheel.*
95. *Particulars of the connections between bogies.*
96. *Effect of the transverse coupling between bogies on the flange wear and on the riding of the vehicles at th nation of curves.*

ADMINISTRATION		Typ	
		Electric locomotives	Diesel electric locomoti
London Transport Executive	Effect of axle play. Effect of intermediate and rear axles. Effect of bogie coupling. Advantages of : *a*) bolsters.		
British Railways (Southern Region)	Effect of axle play. Effect of intermediate and rear axles. Effect of bogie coupling. Advantages of : *a*) bolsters.	Can be critical. No information. No coupling. Not fitted.	
British Railways (Eastern Region)			
Ceylon Government Railways			
Pennsylvania Railroad	Effect of axle play. Effect of intermediate and rear axles. Effect of bogie coupling. Advantages of : *a*) bolsters.	Causes « shimmy, galloping Negligible. No coupling. A bolster improves the gen	
British Railways (London Midland Region)	Effect of axle play. Effect of intermediate and rear axles. Effect of bogie coupling.		
Victorian Government Railways	Effect of axle play. Effect of intermediate and rear axles. Effect of bogie coupling.		

lvantages and disadvantages from the point of view of good riding of bolsters :
a centering arrangement and of a compensating device for the bogies,
an anti-nosing arrangement,
an anti-weight transfer arrangement (unloading of the axles),
coupling of bogies in the lateral plane.

iple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
Not known. 2 axle bogies. lo coupling. ter of some form rs essential to nt bogie motion carried to body.			
n be critical. 2 axle bogies. lo coupling. perience of other s of suspension.			
» when play is excessive. lance of the truck.			
— — None.			
e play can induce vehicle shock and ses hunting and .			

98. *Have you vehicles with motor bogies with three axles? What experience have you got with these b general arrangement drawing of the construction.*

ADMINISTRATION		Electric locomotives	Diesel electric
London Transport Executive	Experience of 3 axle trucks.		
	Experience of 3 bogie vehicles.		
British Railways (Southern Region)	Experience of 3 axle trucks.	Combined with damping of seg. bearing to prevent hunting at maximum speed.	
	Experience of 3 bogie vehicles.	None.	
British Railways (Eastern Region)	Experience of 3 axle trucks.		
	Experience of 3 bogie vehicles.		
Ceylon Government Railways	Experience of 3 axle trucks.		
	Experience of 3 bogie vehicles.		
Pennsylvania Railroad	Experience of 3 axle trucks.	None.	Satisfac (See drawing
	Experience of 3 bogie vehicles.		Non
British Railways (London Midland Region)	Experience of 3 axle trucks.		
	Experience of 3 bogie vehicles.		
Victorian Government Railways	Experience of 3 axle trucks.		
	Experience of 3 bogie vehicles.		

[H]ave you vehicles with three bogies or more and what is your experience in this regard? A general arrange[m]ent drawing of the construction.

[Mult]iple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
None. None.			
None. None.			
	None. 4 coach artic. train units.	None. None.	
None. None.		None. None.	None. None.
None. None.			
None. None.			

100. *Arrangement for avoiding wheel spin.*
101. *Arrangements for giving warning of the commencement of wheel spin.*

ADMINISTRATION		Electric locomotives	Diesel electric loc
London Transport Executive	Avoidance of wheel spin.		
	Indicating devices.		
British Railways (Southern Region)	Avoidance of wheel spin. Indicating devices.	Sanding apparatus. None.	
British Railways (Eastern Region)			
Ceylon Government Railways	Avoidance of wheel spin. Indicating devices.		
Pennsylvania Railroad	Avoidance of wheel spin. Indicating devices.	A relay actuated by speed difference of motors operates a lamp and buzzer.	A relay actuated difference of operates a l reduces moto
British Railways (London Midland Region)	Avoidance of wheel spin. Indicating devices.		
Victorian Government Railways	Avoidance of wheel spin. Indicating devices.		

tiple unit electric motor cars	Multiple unit Diesel electric motor cars	Diesel electric rail cars	Diesel electric shunters
rating relay set so wheel spin shall not r on axle with mi- um adhesive weight. educed T. effort is able for greasy rail itions. The king are offset to give ter adhesive weight otored axles. None.			
None.			
	— None.	— None.	
None.		None.	None.
— None.			
— None.			

102. *Describe in detail the arrangements designed to ease the entry into curves as well as for damping undesirable motion of the vehicle when running.*

Pennsylvania Railroad.

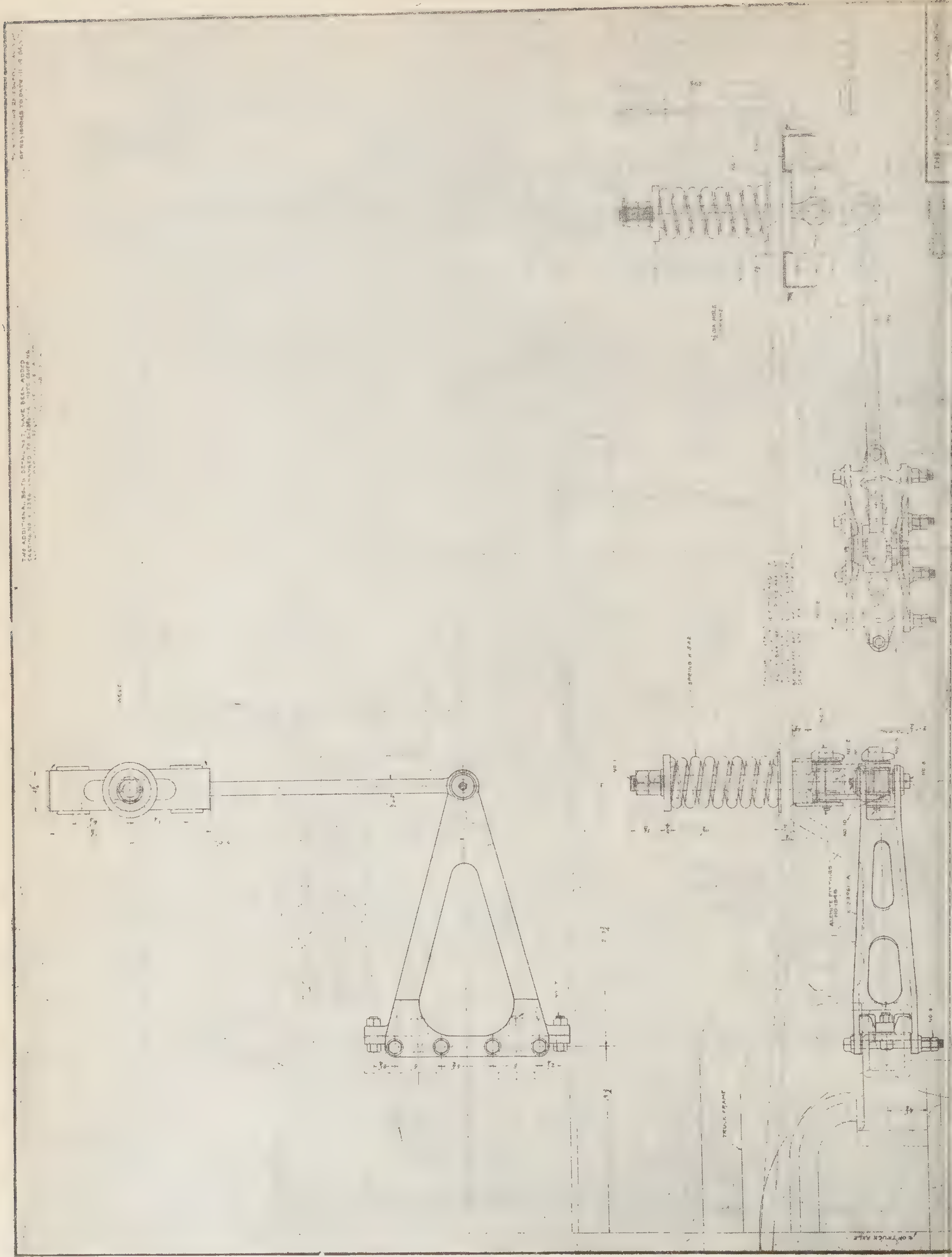


Fig. 9. — Engine truck restraint arrangement. Electric locomotives. *(Pennsylvania Railroad.)*

103. *Results in service of the various types of bogie giving all possible information concerning failure assignable to bogies and to their suspension. Measures taken to avoid their recurrence.*

104. *Comparison of the costs of maintenance of the different types of bogie. Do the results obtained justify the first cost and cost of maintenance?*

London Transport Executive.

(Multiple unit electric motor cars).

Maintenance.

Table below sets out failures for one year :

Failure	No. of occurrences		Remarks
	1938 tube stock	« O » and « P » stock	
Roller axle bearing hot	4	3	Axle box changed.
Roller suspension bearing defective . .	2	—	Sleeve replaced.
Broken motor nose	5	—	Replacement of welded by riveted type has largely overcome this trouble.
Excessive bolster end play	2	—	Due to cushion pad worn or missing. Pad replaced.
Broken auxiliary side spring.	1	—	Replaced.
Broken shoe beam pocket	1	—	Replaced.
Axle journal sleeve loosened.	1	—	Wheels changed.
Bolster binding in pocket.	2	—	Eased.
Brake block adjusting screw defective .	—	3	Renewed.
Brake rod split casting broken.	—	1	Renewed.
Total. . .	18	7	
Car mileage	72 273 552	9 108 164	
Failures per 100 000 car miles. . . .	.025	.0768	

Overhaul.

Difficulty has been experienced with bogies of welded construction due to fractures developing.

The measures adopted to overcome this trouble include stress-relieving (1 hour at 650° C) and the avoidance of carrying welds up to a stressed edge. Electric and acetylene welding are both employed where appropriate but principally the former.

In future designs the bogie will consist of welded side frames with fabricated cross members riveted to them.

Each welded assembly is separately stress-relieved.

The arrangement permits of easy replacement of a whole member, should fractures develop due to faulty material.

Maintenance.

Costs not available as figures cannot be separated from total costs.

Overhaul.

The cost of overhaul of these bogies is estimated to be as follows :

	1938 tube stock		Surface line stock («O» & «P»)	
Labour	14.10. 0.		16.14. 0.	
Stores	7.14. 0.	22. 4. 0.	11.11. 0.	27.15. 0.
Repairs during overhaul.				
Labour	—.16. 6.		3.18. 0.	
Stores	—.16. 6.	1.13. 0.	3.18. 0.	7.16. 0.
Stress relieving	5.10. 0.	5.10. 0.	5.10. 0.	5.10. 0.
		£ 29. 7. 0.		£ 41. 1. 0.

These costs are incurred every four years, so reducing to an annual basis :

1938 tube : £ 7. 3. 0. per annum.

1938 surface £ 10. 5. 0. per annum.

The above do not include any costs concerning wheels, axles, axle boxes or brake blocks.

General.

Experience with other than conventional types of bogie is so limited that comparisons are not possible.

Any changes must conform to the requirements implied by the question.

British Railways (Southern Region).

Electric motor cars.

The performance of these bogies is very good.

Overhaul is carried out every 241 000 km.

Failures include occasional broken side springs and side spring hanger bolts.

No costs are available.

Pennsylvania Railroad.

All types of stock.

The pedestal type of bogie with swing bolster gives satisfactory service. These bogies have hardened cast steel frames and hardened steel axle box liners and horn guides, as well as bushings for bolster swing links and brake pin holes, to facilitate maintenance.

Axles and equalizers are periodically tested for incipient flaws on a « Magna Flux » tester.

No figures on cost of maintenance are available.

Victorian Government Railways.

Electric motor cars.

Pressed plate frame type.

Original type now obsolescent on account of the development of cracks.

Channel sided type.

Limited number only placed in service giving satisfactory service. No failures but replacement will be of the cast steel type.

Cast steel type.

Giving satisfactory service, now the standard replacement bogie.

No figures on costs are available.

(to be continued)

[625 .28]

INTERNATIONAL RAILWAY CONGRESS ASSOCIATION

15th. SESSION (ROME, 1950).

QUESTION V.

Improvements in the construction of rolling stock (motor and trailer) in view of increasing the mileage between repairs :

- **solid wheels or with tyres (metal used for the tyres and solid wheels, behaviour in service);**
- **axle boxes;**
- **wearing and friction metals;**
- **springs (qualities, shape, manufacture).**

REPORT

(America (North and South), Burma, China, Egypt, Great Britain and North Ireland, Dominions, Protectorates and Colonies, India, Iran, Iraq, Malay States and Pakistan),

by E. Pugson,

Chief Officer (Carriage & Wagon Construction and Maintenance), The Railway Executive, British Railways, London;

and L. Lynes,

Technical Assistant to Carriage & Wagon Engineer, The Railway Executive, British Railways, Southern Region, Brighton (Sussex.)

The Questionnaire, which was prepared for Question V, was sent to 26 Administrations.

The Railway Administrations, who have answered the Questionnaire are as follows :

British Railways (The Railway Executive);
London Transport Executive;
Victorian Railways, Australia;
Ceylon Government Railways;
Sudan Railways;
Indian Government Railways;
Pennsylvania Railroad Company, United States of America;
New Zealand Government Railways;
South African Railways and Harbours.

The following have regretted their inability to reply :

Nigerian Railway, West Africa;
East African Railways, Kenya, East Africa;
Burma Railways, Burma;
Iraqi State Railways.

The remainder have made no comments.

***

Introduction.

The following questionnaire refers equally to steam and electric locomotives, self-propelled (including electric) rail cars, electric motor coaches, carriages and wagons.

It has been requested, therefore, that separate replies be given for each of the six types of vehicles mentioned above.

BRITISH RAILWAYS' EXECUTIVE.

The practices of the former Railways now constituting the British Railways are shown; standardisation of these practices is receiving active consideration.

***

LIST OF QUESTIONS.

A. GENERAL.

QUESTION 1.

State the regulations which govern maintenance and periodic repair of locomotives, carriages, wagons, rail cars, etc. What are the conditions of wear of details (e. g. the hollowness of tyre before removal) which have led to the fixing of these regulations?

REPLIES.

BRITISH RAILWAYS.

All Regions.

Steam locomotives.

The shopping procedure is on a uniform basis in all Regions and may be summarised as follows :

The shopping of locomotives for repairs is under the control of the Regional Mechanical Engineer through a regional shopping bureau and is arranged according to the actual condition of the locomotive when considered for repairs.

For the purposes of repairs in Main Works, time periods are specified at which the condition of a locomotive in service is reported to the Mechanical Engineer's shopping bureau by the Superintendent of the Motive Power District to which the locomotive is allocated. The period for each class of locomotive is determined by experience based on the average mileage run per month and the type of work upon which the locomotives are engaged.

The decision as to whether a locomotive should be given repairs or not is based solely on the physical condition as reported, and arrangements are made for locomotives to be reported upon on a subsequent date, decided by the shopping bureau, if condition at the time the first report is made indicates that a shop repair is not then necessary. No precise limits of general application on all Regions are laid down for the conditions of wear which determine shopping, as these must be taken in conjunction one with another.

London Midland Region.

Coaching and wagon stock.

Flange wear — (minimum) (British Railways' Railway Clearing House Regulations) : flange width 7/8″ and 9/16″ from toe of flange.

Tread wear :

Special and class « A » stock (Fast services) : 1/16″ hollow maximum.

Other stock : 3/32″ hollow maximum.

Wagon stock : 3/16″ hollow maximum.

All carriage underframes and bogies must be given a General Repair after a period not exceeding 10 years.

Prior to the last war wagon maintenance programmes were nominally based on the following schedule :

(*a*) Heavy general repairs carried out on an eight yearly cycle (average). This cycle applied to all types of open and covered vans except goods brakes and specially constructed wagons, irrespective of whether of wood or steel construction. No provision is made for the scraping and painting of steel frames at any period between the eight yearly cycles;

(*b*) A six yearly cycle for heavy general repairs of goods brakes and specially constructed vehicles.

(*c*) Main workshop examination and repair to brake equipment of fully fitted vehicles at intervals of four years. Light and minor repairs are carried out at outstation depots.

Electric stock.

	Tyre turning average mileage
Liverpool/Southport	80 000
Wirral	150 000
Euston/Watford	70 000

Eastern and North Eastern Regions.

Electric motor coaches and carriages.

The period over which carriages and electric motor coaches may be run is controlled mainly by the condition of the tyres, bolster clearances and wear on side bearer pads.

Wagons.

Maintained and repaired in accordance with the British Railway's Railway Clearing House Regulations.

Western Region.

Carriages.
3/64″.

Wagons.
3/16″.

Southern Region.

Carriages and wagons.

Dealt with on two yearly basis for light repairs and five yearly basis for general overhaul. No defined limit for tread wear of tyres, carriages and wagons are withdrawn when tyre flanges are worn to the minimum specified by British Railways' Railway Clearing House Regulations.

Multiple unit electric stock.

General overhaul :
Suburban stock : 100 000 miles.
Express stock : 80 000 miles.

Wear on motor wheel tyres the main factor determining the periods.

London Transport Executive.

Examination of passenger rolling stock is carried out at the running sheds every three days by semi-skilled staff and in greater detail every four weeks by a larger number of staff including some tradesmen. Every four years, or 200 000 miles (whichever should be completed first) the cars are overhauled at the central overhaul works.

Victorian Railways, Australia.

Steam locomotives.

Practice card L/15.1.

A periodical examination must be made at each « A » examination, the basis of which is every 1 500 mile; for narrow gauge engines, the basis is every month, whichever comes sooner.

Electric locomotives.

Routine inspection at every 3 500 miles. Lifted for tyres and journal bearings at 50 000 miles.

Electric locomotives used on suburban goods and shunting service : inviting tenders for 17 electric locomotives for passenger and goods trains (45 000 lbs. tractive effort at starting).

Rail cars.

Practice card F/21.

Routine inspection every 4 000 miles. Lifted for tyres and journal bearings at 50 000 miles.

Electric motor coaches.

Practice card F/21.

Routine inspection, every 3 500 miles.
Lifted for tyres and journals at 80 000 miles.

Rail cars, electric motor coaches with suburban trailer cars must be lifted and examined when wheels or journal bearings require attention.

Carriages.

Practice card F/21.

A periodical « lift » must be made, the basis of which is :

Victorian and South Australian joint stock cars and vans : 150 000 miles;

Cars on Melbourne-Mildura (Victoria) run : 12 months;

Certain cars and vans on important express running : 18 months;

Certain other important cars : 2 years;

All other bogie cars : 2 1/2 years.

Wagons.

Practice card F/21.

A periodical lift must be made, the basis varies from 18 months for certain vehicles used on important express running to 7 years for less important and lower speed trains.

Condemning gauges have been developed for application to all tyres of the above groups of rolling stock.

Three sizes viz : 3/4″ flange condemning gauge, used on coupled driving wheels of locomotives rail motor non-driving wheels, cars, vans, and wagons. 13/16″ flange condemning gauge, used on electric locomotives, all cars in electric suburban service, locomotive tender wheels, rail motor driving wheels.

7/8″ flange condemning gauge, used on coupled leading and trailing wheels, pony and certain trailing truck wheels of locomotives.

These gauges indicate that the tyre must be returned :

(*a*) when the flange height exceeds the maximum permitted, or;

(*b*) when the flange contour has excessive wear on tread and bottom fillet, or

(*c*) when flange thickness is below the minimum permitted.

In addition a tyre thickness condemning gauge determines when the tyre has reached the last turning or condemning thickness. The class of service and the load on the wheel decide the latter.

Typical :

Fig. 1 shows the 13/16″ flange condemning gauge and Fig. 2 the method of using it. Fig. 3 shows the tyre thickness condemning gauge and Fig. 4 the method of using it.

Ceylon Railways.

Locomotives.

Mileage basis. Average 40 000 between shopping. Condition : standard C. G. R. tyre profile.

Carriages.

2 1/4 year basis. Standard C. G. R. tyre profile.

Wagons.

4 year basis. Standard C. G. R. tyre profile.

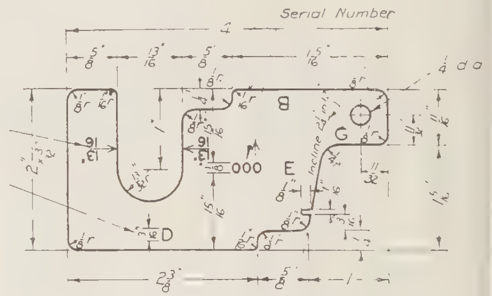


Fig. 1. — 13/16″ Flange condemning gauge for tyres *(Victorian Railways, Australia)*.

Pennsylvania Railroad Co., U. S. A.

The fixing of class (periodic) repairs has been dictated by experience which showed the point at which running repairs were beconming too frequent to justify operating equipment without complete overhaul. Classified repairs are generally made after the following amount of service :

(*a*) *Steam locomotives :* freight 100 000 miles; passenger 125 000 to 150 000 miles;

(*b*) *Electric locomotives :* freight 375 000 miles; passenger 400 000 miles;

(*c*) *Motor rail cars :* 4 years;

(*d*) *M. U. cars :* 4 years;

(*e*) *Passenger cars :* coaches, 4 years; sleeping cars, 3 years; dining cars, 2 years with an intermediate shopping between class repairs for reconditioning and painting;

(*f*) *Freight cars :* 8 to 12 years depending upon type.

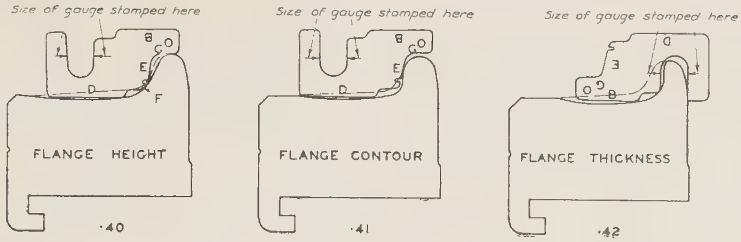


Fig. 2. — Method of using flange gauges. *(Victorian Railways, Australia.)*

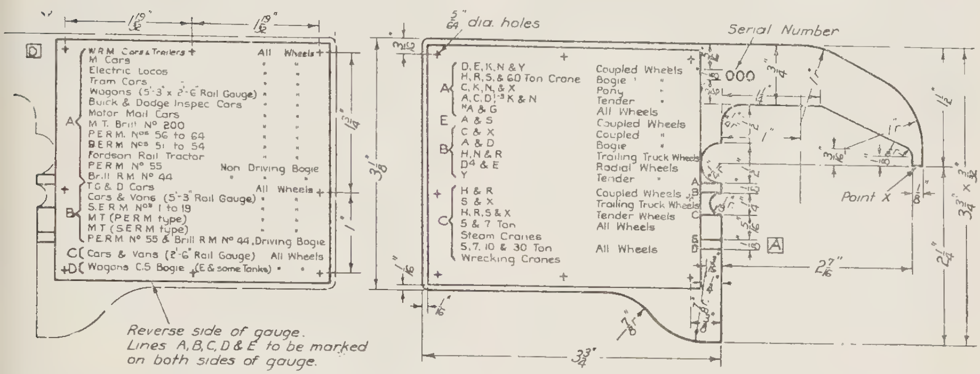


Fig. 3. — Tyre thickness condemning gauge. *(Victorian Railways, Australia.)*

Sudan Railways.

Local regulations lay down heavy repair shopping as follows :

(*a*) *Coaching and wagon stock* — every 2 years.

Fixed as the result of many years experience and governed by the condition of all details; tyres, journals, brake rigging, body condition and paint.

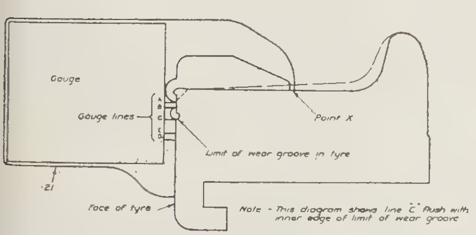


Fig. 4. — Method of using tyre thickness condemning gauge. *(Victorian Railways, Australia.)*

(*b*) *Locomotives.*

Shopped for heavy and light shop repair very largely on condition. « Aim » mileages for heavy repair exist, but decision to shop not rigidly governed by this method.

It is believed that the Sudan with its desert sand and strong wind provides one of the most trying conditions in the world for locomotive wearing parts. As an indication of the operating problems the tyre wear on locomotive driving wheels has long been an extremely expensive problem. After careful experiments a special wear-resisting tyre of 70 ton tensile steel has been adopted but even so under desert conditions the tread wear frequently reaches 5/16″ (measured on radius not diameter) after 10 000 miles running.

In all cases, boiler condition (copper firebox plate wastage, and erosion of tubes, and steel and copper stay wastages) dictates heavy repair.

Regarding light shop repairs, again there are only « Aim » mileages laid down. Varying standards of track, and terrain (loose sand primarily) make shopping for light repairs to be ruled by engine condition. In practice, hollow tyre tread wear, axlebox wear, and slack in motion pins and holes, rule shopping.

Indian Government Railways.

Repairs to locomotives, both in main workshops and running sheds, are regulated on mileage basis. Mileage for workshop repairs varies from 100 000 to 150 000 : should condition of the boiler permit, this mileage can be exceeded. A locomotive may receive one or two intermediate repairs in running sheds or shops between periodical overhauls.

Carriage and wagon stock repaired in workshops on time basis.

Coaches overhauled at intervals of 6 — 36 months depending on the service allocation. Wagons overhauled at intervals of 36 months.

These regulations based on experience of general condition and not specifically on the attainment of any « condemning » limits of wear.

New Zealand Government Railways.

Steam locomotives.

The mileage expected between heavy overhauls is laid down for each class of locomotive in each District, this having been decided from experience. The conditions which determine this mileage are tyre wear, crank pin wear, axlebox wear, piston rod wear and general condition.

Electric locomotives and multiple units.

Period between major overhauls, roughly 200 000 miles, and governed by general mechanical condition. Tyre wear determines intermediate overhauls.

Abbreviated form of code No. 21 used for the above as under :

Locomotive Mileage between « A » overhauls.

Districts	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6 Electric
Various	Varies from 75 000 to 90 000	Varies from 70 000 to 85 000	Varies from 70 000 to 75 000	Varies from 60 000 to 65 000	10 000	Varies from 100 000 to 200 000

Group 4 must be shopped for overhaul at intervals not exceeding four years.

New locomotives.

Before their first overhaul should run a total mileage of 20 % in excess of the schedule mileage in each case.

Mileage to be run by locomotives receiving « B » class repairs.

When locomotives receive intervening «B» class repairs, the total mileage to be run between « A » overhauls should be 50 % in excess of the schedule mileage in each cas.

Rail cars.

4-5 000 miles: inpection of engine.

20-25 000 miles, top-overhaul of engine.

60-70 000 miles, full-overhaul of engine.

Tyre turning becomes necessary between 50 000 and 90 000 miles, but does not render a general overhaul necessary, as the wheels can be changed or removed for tyre turning. General overhaul involving renovation of the bodywork and interior depends on the condition of these items and not on mileage, which may exceed 100 000 miles.

Coaching and wagon stock.

Cars and vans are shopped for overhaul on mileage, the shopping mileage being dependent on the grade of vehicle. The vehicles are graded according to the bogies for this purpose.

Group	Class of Bogie	Miles
a	Roller Bearing	100 000
b	Other 1st grade	85 000
c	Other 2nd grade	50 000
d	Other 3rd grade	40 000

The period between overhauls must not exceed 4 years in any case. General condition of bogies and of bodies and interiors, and condition of bearings, tyres and brake rigging have been the deciding factors. See extract from locomotive code No. 26 below.

« Distribute every four weeks to district mechanical engineers graphs showing mileage run by each vehicle since the previous lift. Cars are by then selected for workshop attention having regard to mileage run and general condition of vehicle.

» Vehicles may be shopped earlier than scheduled at the discretion of the Car and Wagon Inspector. Vehicles which do not reach their scheduled mileage within a period of four years must be shopped at the end of this period.

» When vehicles received in workshops for any purpose have completed 85 % or more of the scheduled mileage for lifting, this operation is to be carried out.

» Vehicles sent to shops for defect repairs not due for lifting have only sufficient work done to make them fit and safe to run. »

South African Railways and Harbours.

Locomotives.

Locomotives are given an intensive examination approximately every 15 000 miles and items which would not give trouble-free service until the next routine stoppage, are repaired or replaced. The only exceptions to this are certain boiler operations consisting of washing out (time intervals between washouts depend on quality of water used) and also the monthly and yearly examinations which are based on time intervals and with which the routine stoppage of the locomotives is now made to coincide.

The above mentioned mileage between routine stoppages was found to be about correct for our conditions. This figure is not immutable and, depending on the types of locomotives involved and the severity of the work performed in service, varies between 10 000 and 20 000 miles.

The main idea behind this scheme is to keep a good locomotive in a good condition and not to rejuvenate an engine in poor condition. This latter aspect is catered for by putting a locomotive through a heavy or an intermediate repair as dictated mainly by the condition of the boiler, the general condition of the locomotive, and its mileage.

Carriages and wagons.

These receive major repairs as follows :

Passenger coaches approximately every 3 years.

4-wheeled wagons (steel bodies) approximately every 6 years.

4-wheeled wagons (wooden bodies) approximately every 4 years.

Bogie wagons (steel bodies) approximately every 4 years.

Bogie wagons and vans (wooden bodies) approximately every 3 years.

Interim light repairs are carried out whenever any particular item requires attention.

Hollow tread wear on wheels of all rolling stock is limited to a maximum of 1/4″. Flanges are permitted to wear until either.

a) The thickness of mid height is reduced from 1 1/8″ (original) to 3/4″ or

b) The inclination of the flange face from the vertical is worn to 15° or less in conjunction with a radius at the tip of 1/4″ or less.

QUESTION 2.

Can it be said generally that mileage between repairs has been increased with improved modern rolling stock and locomotives? If possible give examples.

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

Yes. Improvements such as larger bearing surfaces and special material have increased the mileage between repairs. A good example is the use of manganese steel liners for the wearing surfaces between axlebox and horn guides which have resulted in an increase in mileage between repairs of a certain class of engine from 65 000 to 100 000.

Coaching stock.

Since tyre wear is the usual factor which governs shopping, improvements on rolling stock have not lengthened service between repairs but have tended to lessen the cost of maintenance.

Wagons.

Cast-iron divided type of axlebox which has dowel location between upper and lower portions, see Fig. 5, has given better results than the former type where location is made by means of a tongue and groove joint.

Eastern and North Eastern Regions.

Locomotives.

Mileage between repairs has not shown any marked increase as yet, but there is every indication there will be an increase in miles between general repairs. It is the view that the mile run to-day is a much heavier and faster mile than it was before the improvements, such as large bearings, water treatment, etc., came into effect and, therefore, it can be said that there is greater mileage to-day than in the past.

Western Region.

Yes. Engine mileage between repair has increased in the order of 60 000 to 75 000.

Southern Region.

Steam and electric locomotives.

No degree of certainty that there is improved mileage between repairs with modern locomotives of the types in use on this Region.

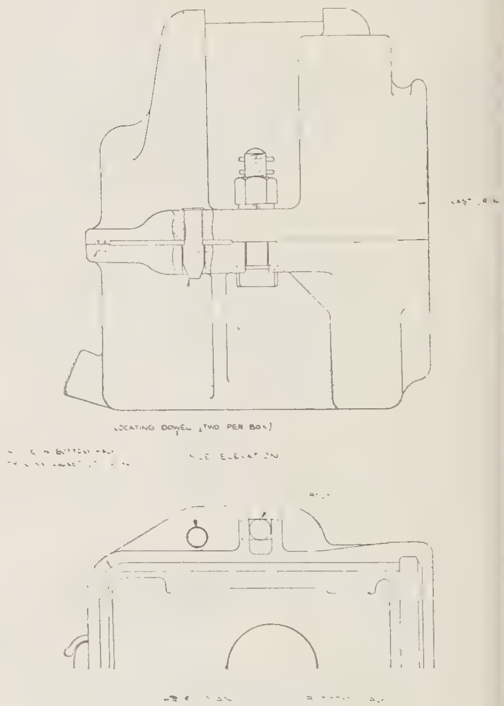


Fig. 5. — Standard divided type oil axlebox. (Railway Clearing House pattern.) *British Railways. Southern Region.*

Carriages and wagons.

No evidence to support this view. The serviceability of wagons is expected to be increased by the use of cast steel and fabricated one piece axleboxes in lieu of the cast-iron divided and one piece axleboxes. Axleboxes of the latter types are frequently broken in hump marshalling yards entailing withdrawal from service and interrupting transport of goods.

London Transport Executive.

Mileage between heavy overhauls has increased from 100 000 miles in 1933 to 200 000 at the present day.

Victorian Railways, Australia.

All types of rolling stock.

No evidence to indicate that mileage has been increased with improved modern rolling stock and locomotives.

Improvements such as the application of roller bearing axleboxes have considerably decreased the maintenance necessary.

Ceylon Railways.

Design has not changed very much for any difference.

Pennsylvania Railroad Co., U. S. A.

Generally mileage has been increased between repairs with modern locomotives and cars as shown by the following examples:

(*a*) Steam locomotives : integrally cast-steel locomotive frames, trucks, and tender frames replaced built-up type constructions. Mechanical lubricators, roller bearings, improved cylinder packing, force feed grease lubrication on valve gear parts and better boiler feed water treatment have all contributed to increased mileage between repairs;

(*b*) Electric locomotives : increased by smoother finish on motor armatures, roller bearings and shortening of periods between routine inspections to determine what running repairs are required to put locomotive in first class condition;

(*c*) Motor rail cars : these cars are in limited use on the Pennsylvania. Replacing gasoline engines with Diesel engines as a safety measure has also increased mileage between repairs;

(*d*) M. U. cars : Askerel insulation for transformers, roller bearings and smoother finish on motor commutators have all contributed to increasing the period between repairs.

(*e*) Passenger cars : Use of aluminium, stainless steel, copper bearing steel and high tensile low alloy steel sheets and shapes, integrally cast steel trucks, roller bearings, and geared generator drives, have increased mileage between repairs.

(*f*) Freight cars : Increased by substituting copper bearing and high tensile low alloy sheets and shapes for the plain carbon steel formerly used, improved draft gears, improved couplers and yokes, cast steel truck sides, bolster spring snubbers, steel running boards, and the improved AB air brake valve.

Sudan Railways.

Generally, no.

Indian Government Railways.

No reliable data.

New Zealand Government Railways.

Steam locomotives.

The use of special steels and of roller-bearing axleboxes enabled a greater mileage to be run between heavy overhauls under world war II conditions and to a greater degree, generally regarded as normal, but the general condition of the locomotives suffers, e. g. from 33 1/3 to 50 % increase over the mileage shown under group I of code No. 21 is common.

Electric locomotives.

Substitution of roller bearings for plain bearings in traction motors has improved the general performance so that the mileage between overhaus has increased from 60 000 to 100-120 000 for the Otira locomotives.

Multiple units.

Not in the case of improved stock which incorporated the latest developments when purchased.

Rail cars.

Only recently used, not possible to make any comparison.

Coaching stock.

Yes. The improvement is indicated to some extent by the grouping shown in reply to Question No. 1.

Wagons.

Yes, particularly with respect to bogie vehicles, due to bogie improvements including fitting of roller bearings.

South African Railways and Harbours.

It is considered that generally mileage between repairs has been increased.

Any modifications considered desirable to reduce maintenance are called for in specifications issued. Any suggestions to this end submitted by tenderers also receive consideration.

Existing locomotives are modified where possible to reduce maintenance costs. This also applies to other rolling stock.

QUESTION 3.

When ordering new rolling stock and locomotives, is consideration given to maintenance costs in the specification, and if when ordering modern stock are endeavours made to reduce these costs? Indicate if the Railway administration endeavours to obtain similar results by the modification of stock in service.

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

Yes. These features have usually been developed as a result of experience, and are applied to existing locomotives if saving in maintenance costs justifies expenditure.

Coaching stock.

Consideration is given to maintenance costs when ordering new stock. The cost of alteration to existing stock is compared with the probable saving in maintenance to determine whether it is economically desirable that such amendments be incorporated.

Eastern and North Eastern Regions.

Consideration is given to reduction of maintenance costs in both new and existing stock.

Western Region.

Yes. Endeavours are also made to obtain similar results, where possible, by the modification of stock in service.

Southern Region.

Steam and electric locomotives.

When designing new locomotives aim is for minimum maintenance when in traffic. Improvements made to new and existing stock when convenient.

Carriages, wagons and electric stock.

New rolling stock has incorporated in its construction the features which experience with earlier designs has shown to be advantageous in respect to material, saving of weight cost and maintenance. Latest applications when economical made to existing stock when parts are renewed.

London Transport Executive.

Yes. During the 4-yearly overhaul the number of parts normally requiring replacement or repair on the motor bogie of a car designed in 1923 amounts to 230, whereas the number on a 1938 tube stock bogie is 52. Modifications to stock already in service to reduce maintenance costs include fitting of roller bearing axleboxes, conversion to non-metallic brake blocks and the fitting of roller bearings to traction motor armatures.

Victorian Railways, Australia.

Yes. Endeavour in specifications for new locomotives or rolling stock to reduce maintenance costs to a minimum, and every practicable improvement is adopted by modification of stock in service with the same end in view.

Ceylon Railways.

Yes. Simple construction, standardization of component parts, etc., are specified.

Pennsylvania Railroad Co., U. S. A.

Consideration is given to maintenance in the specification. All applicable details which have shown superiority in existing equipment are specified for new equipment. Equipment in service is modified to incorporate improved parts as fast as replacement parts are necessary.

Sudan Railways.

(*a*) Consideration is given to maintenance costs when drawing up specifications for new stock.

(*b*) Endeavour to reduce maintenance costs, and obtain longer shopping mileages, by experimental alterations and modification to stock in service.

This applies to locomotives, carriages and wagons.

Indian Government Railways.

Standardization of locomotives and rolling stock undertaken over 20 years ago fostered production economies and consideration given primarily to reliability in operation and low maintenance costs.

Features in standard design have proved to be more economical in maintenance extended to other stock in service when possible to justify the change-over financially.

New Zealand Government Railways.

Steam electric locomotives, multiple units, and rail cars.

Where possible, materials ordered to British Standard Specifications. When ordering new locomotives, consideration given to maintenance costs in the specification, and where a modification has proved economically justifiable, also applied to existing stock, if an ultimate saving would result.

Coaching and wagon stock.

Yes. Where it is advantageous to do so, older stock is altered to incorporate improvements that have been proved.

South African Railways and Harbours.

No answer.

B. SOLID WHEELS.

QUESTION 4.

Have you had experience with solid wheels?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

Yes. Ministry of Supply 2-8-0 « Austerity » tenders only.

Coaching stock and wagons.

Yes. « One-Wear » rolled steel wheels used extensively in recent years for wagons.

Eastern and North Eastern Regions.

Steam locomotives.

Yes. With 2-8-0 « Austerity » locomotive tenders.

Electric motor coaches.

No.

Carriages.

No.

Wagons.

Standard for last ten years.

Western Region.

Locomotives.

Yes. Ministry of Supply 2-8-0 « Austerity » tenders only.

Southern Region.

Locomotives.

Yes (Ministry of Supply 2-8-0 « Austerity » engines). Tenders only.

Carriages, wagons and electric stock.

Yes. « One-Wear » rolled steel wheels used extensively in recent years for wagons.

London Transport Executive.

Yes.

Victorian Railways, Australia.

Steam locomotives.

A few locomotive tenders are fitted.

Electric locomotives.

None fitted.

Rail cars.

Walker Diesel rail cars being supplied from England are fitted with solid wheels.

Electric motor coaches.

Yes.

Carriages.

None fitted.

Wagons.

Yes.

Ceylon Railways.

Yes.

Pennsylvania Railroad Co., U. S. A.

Yes, general use of solid wheels for many years on all types of equipment. Wheels with tyres are used only for steam and electric locomotive driving wheels.

Sudan Railways.

Yes. Largely from approx. 350 wagons (1 400 pairs of wheels) (14 % of total wagon wheels and axle assemblies on lines) which entered service mostly in 1943.

Indian Government Railways.

Solid rolled steel wheels used as permissible alternatives to tyred wheels for many years.

New Zealand Government Railways.

Steam and electric locomotives, multiple units.

No.

Rail cars.

Yes. 14 cars.

Coaching and wagon stock.

No.

South African Railways and Harbours.

Solid wheels have been fitted to bissel bogies and tenders of certain engines, and such wheels are now standard for all carriage and wagon stock except motor coaches.

QUESTION 5.

If so, what are the results which you have obtained or hope to obtain by using solid wheels from the point of view of regularity of the service? What are the advantages and disadvantages already established?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Wagon stock.

No improvements anticipated.

Advantages	*Disadvantages*
(*a*) Less machining allowing larger production from same shop floor space.	—
(*b*) Trouble with loose tyres on goods brakes eliminated.	We have had a very small number of goods brake wheels which have developed radial cracks.
(*c*) Towards the end of the life of tyres on heavy vehicles, the thin tyre is inclined to loosen due to cold rolling in service.	—

(d) Average life of the solid tyre is assumed to be equal to the tyred wheel which is on average 38 years or approximately.	Inability to retyre when worn to minimum.

Eastern and North Eastern Regions.

Locomotives.

Insufficient experience to express an opinion.

Wagons.

Reduced costs.

Western Region.

No information regarding the influence of solid wheels on regularity of the service.

Southern Region.

Locomotives.

No available data.

Carriages and wagons.

None; other than saving of dead-weight and absence of loose tyres. Consider it essential to use cast-iron brake shoes only with this type of wheel.

When non-metallic brake shoes are used for passenger express electric train (automatic Westinghouse brakes) involving high brake shoe pressure there is a risk of such wheels disintegrating through the development of radial surface tread cracks.

London Transport Executive.

Results obtained are satisfactory on non-motored axles only. Depending upon the design of the wheel a slight reduction in the unsprung weight of the wheel and axle assembly is obtained over an equivalent design of tyred-wheel. The removal of worn out solid wheels from their axles permits examination of the axle wheel seats on the « Magna Flux » testing machine. It is necessary to ensure that any holes to facilitate handling or reduce weight are adequately radiused, otherwise circumferential cracks may develop.

Victorian Railways, Australia.

None purchased for many years. The results generally have not been favourable as a good deal of cracking has taken place in the plate adjacent to the boss. The majority of wheels still in service have had the original tyre turned off and a shrunk on tyre fitted. The Walker Diesel rail cars have run a total mileage to date of up to 56 000 miles, not sufficient data yet available to assess their relative merits.

Ceylon Railways.

None.

Pennsylvania Railroad Co., U. S. A.

The results obtained include absence of loose or broken types and cracked wheel spokes.

Sudan Railways.

Solid forged wheels (War Emergency Supply). No statistics comparing resistance to wear of these solid forged wheels with tyred wheels maintained, impression they have worn very well indeed.

Indian Government Railways.

Solid wheels produced quicker and more cheaply. Subsequent maintenance may not be higher if they are rolled initially with a sufficient depth of rim to take a tyre of standard thickness after several turnings. Such wheels suffer from one disadvantage, namely, if the material is defective it involves the scrapping of a larger component. Experience too limited to offer a more comprehensive reply.

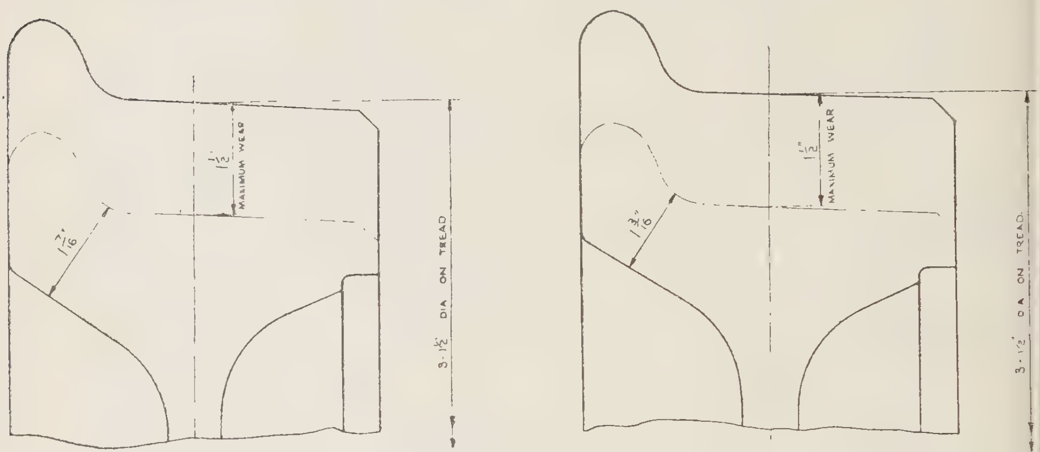
New Zealand Government Railways.

Rail cars.

Dependability. Freedom from risk of failure on high speed work and of loosening

Sections « one wear ». Solid rolled steel railway wheels.

20 ton *wagon.* 13 ton *wagon.*



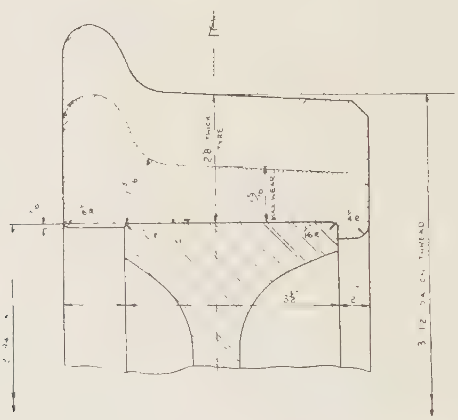


Fig. 6. — Suggested method of re-tyring « one wear » wheels for 13 ton wagons.

of tyre when the speed is high, and there is a heavy braking load. The results are entirely satisfactory.

South African Railways and Harbours.

The advantages of the particular wheel used lay principally in the fact that it was interchangeable with carriage and wagon wheels.

Some trouble with shelling of the tread was experienced when such wheels were used, under constant heavy loads, in conjunction with roller bearings.

In the case of bissel bogies difficulty was also experienced after the solid wheels had been re-tyred, due to the standard carriage and wagon tyre used providing for less wear than the engine coupled-wheel tyres, thereby precluding all tyres being turned

equally and necessitating awkward spring gear adjustments.

For the above reasons wheels initially fitted with tyres are now preferred for engines and tenders, although solid wheels are preferred for other rolling stock.

QUESTION 6.

The same question from the cost point of view.

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Coaching stock.

Solid wheels have been used mainly on wagon stock.

Experience with the solid wheels is too short to give definite information. It is considered that solid wheels should be of such dimensions as would make it possible to fit a tyre after the first life has been obtained : see proposal Fig. 6.

Eastern and North Eastern Regions.

Wagons.

Reduced costs.

Western Region.

Lower cost of solid wheels.

Southern Region.

Locomotives.

No available data.

Carriages and wagons.

Lower first cost. Where earlier wheels of this type have been used for carriages they have been turned down to receive « shrunk-on » tyres. The practicability of applying tyres to worn « one-wear » wagon wheels has been investigated and proposals are shown on Fig. 6.

London Transport Executive.

Many factors affect the question, but providing the wheels are rolled from steel of a specification that will give statisfactory wear, there is little to choose between the cost over a period of 30 years between tyred and solid wheels for non-motored axles.

Victorian Railways, Australia.

1938 investigation re car and wagon wheels show following relative costs :

New wheels delivered at Newport Workshops :

Solid wheel £ 15.13.6.
Spoke wheel £ 15.6.8.

Upon reaching tyre condemning limit cost of replacement :

Solid wheel £ 16.3.6.
Spoke wheel £ 8.7.0.

Alternatively converting solid wheel to wheel centre and installing a new tyre : £ 12.7.9.

Considered more economical to use wheel centres with a shrunk on tyre, and now the standard practice adopted.

Ceylon Railways.

Initial cost of solid wheels less than tyred wheels.

Pennsylvania Railroad Co., U. S. A.

Cost of tightening tyres by shimming, welding spokes, and maintaining stock of tyres, retainer rivets, shims, etc., is eliminated.

Sudan Railways.

Insufficient experience.

Indian Government Railways.

See answer to question 5.

New Zealand Government Railways.

Railcars.

After the wheels are worn down to condemning diameter they are used as wheel centres for car and wagon stock. Hence the cost aspect is also satisfactory.

South African Railways and Harbours.

Comparative initial costs of rolled and cast wheels are not available but rolled wheels, if of a type produced in large quantities, are obviously cheaper than cast wheels. A longer initial life is obtained on carriage and wagon stock from wheels having solid treads.

QUESTION 7.

Do you use solid wheels on vehicles running at high speeds?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Coaching and wagon stock.

Yes, for vacuum fitted freight stock and to a limited extent for some coaching stock.

Experience dates from 1926.

Eastern and North Eastern Regions.

Wagons.

Used on express freight trains.

Western Region.

On vehicles in goods trains only.

Southern Region.

Locomotives.

No.

Carriages and wagons.

Used only for vacuum brake fitted wagons working at high speeds with cast-iron brake shoes — braking efficiency 100 % = tare weight : and also for 25 - ton goods brake vans (fitted with handbrakes) to avoid loose tyres when operating severely graded routes.

London Transport Executive.

Solid wheels are fitted to vehicles having a maximum specified speed of 60 m. p. h.

Victorian Railways, Australia.

No. Speed for Walker Diesel rail cars — 45 miles per hour.

Speed for electric motor coaches — 5[illegible] miles per hour.

Ceylon Railways.

Yes. Maximum speed on C. G. R (45 miles per hour) cannot be considere[illegible] a high speed.

Pennsylvania Railroad Co., U. S. A

Solid wheels are used on locomotive and cars operating at the highest authorize speeds on the railroad.

Sudan Railways.

No distinction made between tyred an solid wheeled stock. Sudan Railwa speeds are comparatively low.

Indian Government Railways.

Maximum speeds in India are 60/6 m. p. h. and solid wheels are used o vehicles up to these maxima i. e. no speci restrictions.

New Zealand Government Railway

Rail cars.

Yes.

South African Railways and Harbour

Solid wheels are used on vehicles runni at high speeds-South African Railwa speed limit 55 m.p.h. at present.

QUESTION 8.

Do you use them on braked vehicles (brak on running surface, on brake drum, or on wheel centres)? What material is used brake shoes? What advantages and disadv tages have been established?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Coaching and wagon stock.

Yes. Braked on the running surface of tyre with cast-iron brake shoes. Loose tyres on goods brakes eliminated.

Eastern and North Eastern Regions.

Wagons.

Yes, with surface braking. Cast-iron brake shoes.

Western Region.

Solid wheels are used on many vacuum fitted freight vehicles with cast-iron brake shoes operating on the rims of the wheels. Solid wheels are not used on goods brake vans.

Southern Region.

Locomotives, carriages and wagons.

Yes. Brake on tread of tyre. (See also answers to Questions 5 and 7.)

London Transport Executive.

Yes; and braked by means of non-metallic brake blocks applied to the tread of the wheel. No disadvantage, the results being generally uniform for solid wheels of equivalent specification and service. Experience with solid wheels on motored axles shows that the rate of wear is too rapid to make them an economical proposition for this duty on our service.

Victorian Railways, Australia.

Yes, with ordinary brake blocks making contact with the surface of the tyre tread. The material is known as B. B. 1. — F. 4. Brake block iron with composition adjusted to produce Brinell Hardness Range 220-250.

Ceylon Railways.

Yes. Braked on running surface; cast iron. Brake blocks.

Pennsylvania Railroad Co., U. S. A.

Solid wheels are used with conventional brakes, having the shoes contact wheel treads during braking action. Cast iron shoes with sheet steel back are used. Advantages are simplicity and low cost.

Sudan Railways.

Used on braked vehicles. Cast iron brake shoes standard, braking on running surface. Found no advantage or disadvantage with cast-iron shoes on tyred as compared with cast iron shoes on solid wheels.

Indian Government Railways.

Solid wheels used on braked vehicles with braking on tyre tread. Cast iron brake shoes standard. No special advantages or disadvantages known.

New Zealand Government Railways.

Rail cars.

Yes. Braking on running surface. Shoes are cast iron. Where braking is on a drum, an asbestos moulded shoe is used.

South African Railways and Harbours.

Solid wheels are used on braked vehicles — e. g. tenders and carriages and wagons, the brake shoes operating on the running surface. The material used for brake shoes is cast iron. Except for limited numbers of ferodo brake blocks used experimentally pre-war on carriage stock no other material has been used. Cheapness of cast iron is the major feature.

QUESTION 9.

What metal is used for solid wheels (chemical analysis and physical characteristics)?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Locomotives.

Rolled steel wheels used for Ministry of

Supply 2-8-0 « Austerity » type. Engine tenders only, and satisfactory.

Cast-iron solid wheels used for the tenders of 50 American 2-8-0's. Wheels found unsatisfactory.

Coaching and wagon stock.

Solid wheels are purchased to L. M. S. Specification No. 36A; particulars below :

Class	Acid or Basic	Analysis		Tens. strenght tons per sq.in.	Minimum Elongation %
		S. Max.	P. Max.		
«B»	Acid or Basic	0.060	0.060	42 to 48	18 to 15
«C»	Acid	0.050	0.050	50 to 55	13 to 11

During the last war basic steel was accepted for both classes of wheels and this relaxation has not been rescinded.

Eastern and North Eastern Regions.

British standard specification No. 468B, dated 1932.

Steel Class « B » or « C ».

Western Region.

Locomotives.

Used solid rolled steel wheels for tenders only of 2-8-0 « Austerity » type. Also cast-iron wheels were used for tenders of American 2-8-0 engines; these gave trouble and were replaced by solid cast steel wheels.

Wagons.

Purchased in accordance with British standards specification 468B (Class C).

Typical analysis :

Carbon .... .54%
Silicon...................... .27%
Manganese .... .80%
Sulphur .... .031%
Phosphorus................. .023%

Southern Region.

Locomotives.

Rolled steel wheels used for Ministry of Supply 2-8-0 « Austerity » engine tenders only : satisfactory.

Wagons.

Steel conforms to British standards specification No. 468A dated 1932. Wagons only. Class C.

Acid or Basic	Analysis		Tens. strenght t per sq. in.	Minimum elongation per cent
	S. Max.	P. Max.		
Acid preferred	0.05 %	0.05 %	50 to 55	13 to 11

London Transport Executive.

The physical properties required of the rims of solid wheels are :

U. T. S. — 56 — 62 T/D".
Elongation — 13-11 %.
Impact — Over 40 ft. lbs. izod.

Solid wheels are of ordinary carbon steel, the analysis of which should fall within the following limits :

Carbon : .5 — .6 %.
Manganese : .65 — .85 %.
Sulphur : not to exceed .04 %.
Phosphorus : not to exceed .04 %.

Victorian Railways, Australia.

Highest quality steel made by the open hearth process. The wheel is made in one piece from a section of an ingot of high tensile steel forged by a powerful hydraulic press and then rolled.

The tensile strength 56 to 62 tons per sq. in., elongation 10 to 8 per cent, in a gauge length of 2 ins.

Ceylon Railways.

Conform to British standard specifications.

Pennsylvania Railroad Co., U. S. A.

The steel analysis for solid wheels is shown by the following tabulation :

Carbon : wheels not heat treated 0.65 to 0.77 %.

Carbon : heat treated Class A, not over 0.63 %.

Carbon : heat treated Class B, 0.57 to 0.67 %.

Carbon : heat treated Class C, 0.67 to 0.77 %.

Manganese : 0.60 to 0.85 %.
Phosphorus : not over 0.05 %.
Sulphur : not over 0.05 %.
Silicon : not less than 0.15 %.

The heat treatment consists of heating the entire wheel to the proper temperature required to refine the grain and then quenching. Immediately following the quenching, wheels are reheated for tempering to the required hardness. The required hardness for the different classes is :

Class	*Brinnel hardness number.* *Minimum*	*Maximum*
A	255	321
B	277	341
C	321	363

Sudan Railways.

Not known.

Indian Government Railways.

Carriages and wagons.

(Indian Railway standard specification.)

Adcie or Basic	Analysis S. Max.	Analysis P. Max.	Tens. strength per sq. in.	Minimum elongation %
Approved process.	0.05 %	0.05 %	50 to 55	13 to 11

New Zealand Government Railways.

Rail cars.

Taylor Bros. « Empire 70 » steel or steel Peech and Tozers C. P. 70 ton. quality.

South African Railways and Harbours.

Steel : Maximum sulphur 0.04 %.
Maximum phosphorus; 0.04 %.
Tensile strength 63 to 69 tons per sq. in.
Minimum elongation 10 % to 8 %.

QUESTION 10.

Do you use special methods of manufacture in order to obtain the appropriate characteristics of the metal in the different parts of the wheel?

REPLIES

BRITISH RAILWAYS.

London Midland Region.

No. Do not manufacture.

Eastern and North Eastern Regions.

Wagons.

No. Solid wheels used as supplied by contractors.

Western Region.

Solid wheels are ordered to British standard specification 468B (Class C), heat treatment or method of manufacture to obtain the specified mechanical properties is not stipulated.

Southern Region.

Locomotives, carriages and wagons.

No. Used as received from manufacturers.

London Transport Executive.

Solid wheels are normalised at 800 — 850°C. and the rims are hardened by cooling at an accelerated rate through the critical range. The rim is then allowed to recover at a temperature between 550° and 650°C. according to the carbon content.

Victorian Railways, Australia.

No.

Ceylon Ralways.

No replies.

Pennsylvania Railroad Co., U. S. A.

The rim of the wheel is heat treated by the above method; the plate and hub are not heat treated.

Sudan Railways.

Do not manufacture.

Indian Government Railways.

Use no special process.

New Zealand Government Railways.

Rail cars.

Wheels are purchased.

South African Railways and Harbours.

Wheels not manufactured by South African Railways.

QUESTION 11.

Can the solid wheels which you use be re-profiled, by the depositing of metal, by turning, etc., and what are the thickness limits in each case?

REPLIES

BRITISH RAILWAYS.

London Midland Region.

A number of machines are used for depositing of metal at the roots of flanges thus saving half the amount of metal it would otherwise be necessary to turn for the profile to bring it back to standard.

Eastern and North Eastern Regions.

Wheels can be profiled by turning. Depositing of metal not generally adopted.

Western Region.

Re-profiled by turning minimum tread thickness 15/16″.

Southern Region.

Locomotives, carriages and wagons.

Yes, by turning. Excessive turning is restricted by use of witness mark when reprofiling.

Minimum thickness 15/16″ for wagons accords with British Railways' Railway Clearing House requirements.

London Transport Executive.

Solid wheels are re-profiled only by turning. A wheel 31″ dia. and 3″ rim thickness when new, is scrapped when the rim thickness falls below 1.1/2″.

Victorian Railways, Australia.

Yes; by re-turning the tyre contour.

The instructions regarding the treads and flanges of tyres apply similarly to the solid wheels.

Ceylon Railways.

Only by turning down and shrinking on new tyres. Condemning thickness 7/8″.

Pennsylvania Railroad Co., U. S. A.

Re-profiled by turning. Do not restore wheel treads to proper contour by depositing metal on the tread surface. The thickness condemning the limit of the wheel rim, measured at the centre of the tread, is 3/4″ in freight service and 1″ in passenger service.

Sudan Railways.

Yes — by turning.

Indian Government Railways.

Re-profiling done by turning to next smaller diameter. Have never experimented

with the depositing of metal on worn tyres. The amount of metal removed by turning depends upon the wear on the tread and the flanges.

New Zealand Government Railways.

Rail cars.

No welding permitted. The wheels turned and reprofiled until the condemning diameter is reached.

South African Railways and Harbours.

Depositing of metal by welding is not permitted. Wheels can be re-profiled by turning required amount off tread.

Final turning size for solid wheel is determined by internal diameter of tyre which will eventually be fitted.

QUESTION 12.

In the case of wheels having flats do you repair on site by building up by welding and making good the tyre surface by grinding or turning?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

No.

Eastern and North Eastern Regions.

Wagons.

Turned when necessary.

Western Region.

No.

Southern Region.

Locomotives and carriages.

No.

London Transport Executive.

No welding of solid wheels is permitted.

Victorian Railways, Australia.

No. The welding of tyres is absolutely forbidden under any circumstances.

Ceylon Railways.

No.

Pennsylvania Railroad Co., U. S. A.

Wheels with flat spots are restored to proper tread contour by grinding or turning No welding on wheel treads permitted.

Sudan Railways.

By turning.

Indian Government Railways.

Welding is not permitted.

New Zealand Government Railways.

Rail cars.

When flats are formed generally it is only necessary to grind off the « pick-up » to make the tread serviceable again. Welding is not permitted.

South African Railways and Harbours.

No. Welding on wheel treads is not permitted. Wheels with excessive flats are removed from vehicles. and turned down to smaller diameters.

QUESTION 13.

After several re-turnings are you able to retyre wheels which originally were solid weels?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Coaching stock.

No.

Wagon stock.

No, except for early type of « Schoen » wheels used on goods brakes.

Eastern and North Eastern Regions.

Wagons.

Yes, but method used has not been perpetuated on account of cost.

Western Region.

No, but matter under consideration.

Southern Region.

Locomotives.

Yes : fitted with lipped tyres (See reply to Question 16).

Carriages and wagons.

See answer to Question 6.

London Transport Executive.

It is possible to re-tyre some designs of solid wheels and this has been done in certain cases in the past though not as a general practice.

Victorian Railways, Australia.

Yes, when in good condition.

Ceylon Railways.

Yes.

Pennsylvania Railroad Co., U. S. A.

Solid wheels, when worn to limit, are scrapped. Do not reclaim solid wheels by applying tyres.

Sudan Railways.

No. The rim thickness is insufficient.

Indian Government Railways.

Re-tyre the wheels after several returnings. Provision for this made in the initial rolled wheel centre, otherwise the tyre may have to be of lower than standard thickness.

New Zealand Government Railways.

Rail cars.

The condemned wheels are removed from railcar service, and turned down for use as wheel-centres for cars and wagons.

South African Railways and Harbours.

Yes. Tyres are fitted after solid wheels reach minimum diameter.

QUESTION 14.

List the defects such as shelling, scaling, radial cracks or others? Are these defects more or less frequent with solid than with tyred wheels?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Locomotives.

No.

Coaching and wagon stock.

Cases of shelling and scaling occur occasionally in each type. A very few cases of radial cracking have occurred on goods brake wheels.

Eastern and North Eastern Regions.

Wagons.

No.

Western Region.

No reliable data available.

Southern Region.

Locomotives.

No data.

Carriages and electric stock.

Respecting solid wheels see answer to Question 5.

Solid wheels of electric stock have shown all the defects listed when working with non-metallic brake shoes. This stock is heavily braked, service conditions are

hard and brake applications are frequent. Wheels are withdrawn from service. Practically no trouble with wheels when cast-iron brake shoes are used.

London Transport Executive.

Shelling and thermal cracking of tread surfaces occur in both solid and tyred wheels. It is thought that the severity would be about the same for both types, given similar loading and service conditions. Our experience is that the condition develops to a serious degree only under the more arduous conditions obtaining on the motored wheels.

Victorian Railways, Australia.

(*a*) See reply to Question 5.
(*b*) No evidence.

Ceylon Railways.

No replies.

Pennsylvania Railroad Co., U. S. A.

Tread defects are encountered in about the same proportion on wheels with tyres as they are on solid wheels.

Sudan Railways.

No defects such as listed, with either kind of wheel.

Indian Government Railways.

Experience with solid rolled steel wheels limited. Defects unknown.

New Zealand Government Railways.

Rail cars.

None experienced.

South African Railways and Harbours.

Shelling and scaling of tread has been observed when solid wheels are used, under continuous heavy loads, in conjunction with roller bearings.

These defects have not been observed to same extent on carriage and wagon stock on tyred wheels.

C. TYRED WHEELS.

QUESTION 15.

What quality is the metal of tyres (chemical analysis and physical characteristics, method of manufacture and especially type of heat treatment)?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Locomotives, carriages and wagons.

We do not manufacture tyres, they are purchased to L. M. S. specification 8D, particulars below :

Class	Acid or basic	Analysis. S. Max.	Analysis. P. Max.	Tens. strength tons per sq. in.	Minimum elongation %
«B»	Acid or basic	0.050	0.050	42 to 48	18 to 15
«C»	Acid	0.050	0.050	50 to 55	13 to 11
«CB»	Acid	0.040	0.040	50 to 55	18 to 15
«DC»	Acid	0.040	0.040	56 to 62	13 to 11

A falling weight test is also specified. Basic steel is accepted in place of acid as in Question 9.

Eastern and North Eastern Regions.

Steam locomotives.

British standard specification No. 4. Report 24. Part 2. 1942. Tyres 5′—6″ internal diameter and above.

Class « C ». Tyres under 5′—6″ internal diameter.

Class « D ». Tyres 6′—0″ and over external diameter and certain other types below this size, oil hardened and tempered.

Carriages, including electric motor coaches.

British standard specification No. 5.

Report 24. Part 2. Dated 1942. Tyres Class « D ».

Wagons.

See answer to Question 9.

Western Region.

Specifications.

B. S. Report No. 24. 1942.

Spec. No. 4 — Locomotive tyres — Class « C ».

Spec. No. 5 — Carriage tyres — Class « C ».

Spec. No. 5 — Wagon tyres — Class «B».

Open hearth acid of basic steel at manufacturers' option.

Typical chemical analysis.

	C	Si	Mn	S	P
Locos and Carrs.	.55 %	.25 %	.85 %	.04 %	.04 %
Wagons	0.47 %	.25 %	.75 %	.04 %	.04 %

Heat-treatment.

No heat-treatment is specified but manufacturers are allowed to oil quench and temper or normalise at their option. About 50 % of our tyres are supplied « as rolled ».

Southern Region.

Locomotives.

Majority of tyres ordered to British standard report 24. Specification 4. Dated 1942. Class « D ».

Some tyres for express engines are made to Messrs. Firth, Brown's Q. 309 Steel.

Steel	B. S. S. 24/4 Class D	Q. 309
Tensile	56-62 tons per sq. in.	63-69 tons per sq. in.
Elongation . .	11-9 % on 2″	10-8 % on 2″
Carbon. . . .	.65 %	.42 %
Silicon	.23 %	.28 %
Manganese . .	.76 %	1.37 %
Nickel	.14 %	.20 %
Chromium . .	.13 %	.76 %
Molybdenum .	—	.47 %
Sulphur . . .	Not more than .04 %	.029 %
Phosphorus . .	Not more than .04 %	.027 %
Method of manufacture . .	Acid open hearth or electric process	Acid open hearth
Heat treatment	Oil hardened and tempered	Oil hardened and tempered

Carriages wagons and electric stock.

Tyres purchased from manufacturers comply with British standard Institute Report 24 Part 2. Specifications 5 and 5*a*. Dated 1942. See also London Midland and Western Regions' replies.

Steel Class « B » (without analysis) acid or basic — wagons.

Steel Class « C » (with analysis) acid — carriages, electric stock, trailer bogies, and goods brake vans.

Steel — Class « E » (with analysis) acid — electric stock motor bogies.

Physical properties (extracted from above specification).

Ultimate tensile stress.

Tons (lb) per sq. in.	Kg per mm^2	Minimum elongation per cent
63 (141.120) to 69 (154.560)	99.22 108.67	10 8

Typical chemical analysis Class « E ».

Carbon	.77%
Manganese	.75%
Silicon	.22%
Sulphur	.047%
Phosphorus	.048%
Oil-hardened	850° C.
Tempered	590° C.

Heat-treatment.

The tyres may be supplied with or without heat-treatment at the option of the manufacturer.

London Transport Executive.

The quality of the metal used for tyres is :

U. T. S. 56 — 62 T/D″ elongation 13 — 11 %.

Impact — Over 40 ft. lbs. izod.

The chemical analysis is : —

Carbon — .40%.

Silica — .25%.

Manganese — 1.45%.

Molybdenum — .48%.

Chronium — .65%.

Nickel — not to exceed 0.7%.

Sulphur — not to exceed 0.46%.

Phosphorus — not to exceed 0.46%.

Heat treatment consists of oil hardening from approx. 850° C and tempering to approx. 660° C.

Tyres are rolled to approximately the required profile, bored to size and finally turned after mounting on the wheel centre.

Victorian Railways, Australia.

Steam locomotives.

(*a*) For 6′—0″ diameter locomotive coupled wheel tyres.

Class of steel	Process of manufacture	Percentage of S.	Percentage of P.	Tensile breaking strength t per sq. in.	Minimum elongation per cent
« C »	Acid open hearth Basic open hearth Electric	.05 .04 .04	.05 .04 .04	over 49 up to 56 over	with 14 to with 11
(b) For all other locomotive and tender wheel tyres.					
« D »	Acid open hearth Basic open hearth Electric	.05 .04 .04	.05 .04 .04	over 56 up to 63	with 10 to with 8

Electric locomotives, rail cars, electric motor coaches, cars and wagons.

Steel Class « D » as for steam locomotives.

Method of manufacture : tyres are rolled from the highest quality of steel made from the best selected material by the acid or basic open hearth or electric processes, as may be specified. They shall be free from injurious defects and finished in a workmanlike manner. The tyres may be supplied with or without heat treatment at the option of the manufacturer.

Ceylon Railways.

Conform to British standard specifications.

Pennsylvania Railroad Co., U. S. A.

Tyred wheels on the Pennsylvania used for steam and electric locomotive driving wheels only. The analysis of the open hearth or electric furnace steel used is :

Carbon — Passenger locomotives 0.50 to 0.65 %.

Carbon — Freight locomotives 0.60 to 0.75 %.

Carbon — Switching locomotives 0.70 to 0.85 %.

Manganese 0.50 to 0.75 %.

Phosphorus not over 0.05 %.

Sulphur not over 0.05 %.

Silicon 0.15 to 0.35 %.

Physical properties are :

	Passeng.	*Freight*	*Shifting*
Tensile strength p. s. i.	105 000	115 000	125 000
Elongation in 2″ per cent.	12	10	8
Reduction of area per cent.	16	14	12

No heat treatment given to tyres. The tyres, immediately after being rolled, are slowly cooled in such a manner as to prevent injury by too rapidly cooling below the critical range.

Sudan Railways.

All carriages and wagon tyres.

Standard for Sudan Railways is British standard specification 24 — Part 2. Class « D ».

All locomotive tyres. Coupled and carrying.

Carbon	0.72 — 0.76
Silicon................	0.213 — 0.323
Manganese	0.70 — 0.76
Sulphur	0.037 — 0.044
Phosphorus............	0.038 — 0.046
Molybdenum	0.17 — 0.20
Maximum stress	70.5 —77 tons
Tons per sq. in. yield point	46 — 52 tons
Tons per sq. in. elongation per cent. on 2″..	14 — 16 % tons
Reduction of area per cent. on 2″	29 — 34 % tons

Heat treatment is provided by manufacture.

Indian Government Railways.

Steel Tyres for locomotives and other rolling stock.

(Extracts from Indian Railway Specification No. R. 15/49).

Quality of Steel.

Acid Open Hearth or any such modification of the Acid Open Hearth Process as approved.

Chemical Analysis.

Not more than 0.05 % Sulphur, and 0.04 % Phosphorus.

Physical Properties :

CLASS	Tensile breaking strength tons (lbs.) per sq. in.	Minimum Elongation per cent.	Minimum Yield Point per cent. of Tensile Strength.
Carriage and wagon tyres. . . .	50 (112 000) to 56 (125 440)	13 / 11	50
Locomotiv and tender tyres. . .	56 (125 440) to 62 (138 880)	11 / 9	50
Electric locomotive tyres	63 (141 120) to 69 (154 560)	10	50
Tyres of motor vehicles of electric stock	70 (156 800) to 77 (172 480)	10	50

Heat Treatment.

A the option of the manufacturer.

Forged or Rolled Steel Wheel Centres.

Carriages and Wagons.

(Extracts from Indian Railway Specification No. R. 19/39).

Quality of Steel.

Acid or Basic Open Hearth Process.

Chemtcal Analysis.

Not more than 0.06 % Sulphur or Phosphorus.

Physical Properties.

Tensile strength tons per square inch	Minimum elongation per cent
33/40	22/15

New Zealand Government Railways.

Locomotives and other rolling stock.

Not inferior to B. S. S. Report No. 24. Part 2. Spec. 4/1942 class D. For the more important locomotives :

Steel Peech and Tozers « C. P. » quality steel.

Taylor Bros. « Empire 70 » steel.

Baker and Bessemers « India » steel.

South African Railways and Harbours.

Steel. British Standard report No. 24, Part 2, specification No. 4/1928 class E (63 to 69 tons per square inch.)

QUESTION 16.

What are the measures that you have adopted to reduce to a minimum the risk of loose tyres? (State of surface after machining, diameters of the wheel centres and tyres in contact before mounting, system of heating tyres, etc.). Do you weld at the rim to prevent loose tyres?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Locomotives.

Tyres and wheel centres are finished with a smooth surface which is produced by carbide tools with a fine feed and light cut. When re-tyring the wheel centre the rim is turned up if any corrosion evident, or if it exceeds .025″ out of round.

Diameters of wheel centres and tyres before mounting :

Diameter in inches of wheel centres = D″

$$\text{Nominal tyre shrinkage} = \frac{D''}{1200}$$

Nominal tyre shrinkage. Tolerance = .005 ins.

Tyres are heated in a gas ring formed of movable segments, until the wheel centre can be lowered into the bore of the tyre without interference. Allowed to cool off after assembly.

Do not weld at rim.

Corrosion of tyre bore and wheel rim is a factor which encourages loosening of tyres, and as a step to prevent this, a trial has been made with a heat resisting graphite base paint which is applied to the bore before shrinking-on the wheel centre. This trial has not yet proceeded far enough to decide what effect it has had in preventing loose tyres.

Coaching stock.

Carriage and wagon tyres are shrunk on and secured by « Gibson » retaining rings.

Particulars of tolerances and machining are given finish below :

Wheel rim :

	Tolerance
Turned with high speed steel flat tool, watercut finish	+ .000
	Nom. — .000

Tyre :

	Tolerance
Bored with high speed steel round nose tool.	+ .000
	Nom. — .005″

Shrinkage allowance .048″ on 3′—2″ diameter (wheel centre).

The tyre is heated by a circular pipe pierced at intervals to form burners for a gas and air mixture or by Selas equipment.

Do not weld at the rim.

Eastern and North Eastern Regions.

Steam locomotives.

A fine finish is given to the bore of the tyres and the rims of the wheel centres by means of Tungsten carbide tools at cutting speeds of 500′/600′ per minute; and a feed of 1/64″ to 1/96″.

When the tyre is bored a small strip 1/2″ wide is turned cylindrically on the tread of the tyre.

The circumference of the tyre at the strip is then measured with a steel tape, after the tyre has been shrunk on it is again measured to check the amount of expansion and should this not fall between predetermined limits it must be taken off.

Typical limits are as follows :

Dia. of wheel	Dia. of wheel-centre	Grip allow. on inside dia. of tyre	Normal circumf. in ins. on outside of tyre = C	Allowance for expansion in circumference
6′—8″	6′—2″	$\frac{D}{800}$	251.33	Maximum $\frac{C}{800} = 0.314''$ Minimum $\frac{1}{1340} = 0.187''$

The tyre is also secured to the wheel by rivets opposite each alternate spoke.

In addition, attention has recently been given to the design of locomotive wheel rim sections to ensure a greater rigidity between the spokes.

Carriages.

The bore of tyres and rims of wheel centres are smoothly machined. Shrinkage allowance $\frac{1}{800}$ of internal tyres diameter.

The tyres before shrinking on are heated to the required temperature by gas burners arranged continuously around the outer periphery of the tyre.

There is no welding of tyres on to the wheel rim.

Wagons.

Tyres bored 1/16″ diameter less than diameter of wheel centre. Machined as for carriages.

Western Region.

Insertion of key ring (Gibson type). Surface of parts in contact — fine machine finish.

Locomotive tyres shrinkage allowance of

$$\frac{1.385D - 10}{1000}$$

where D is rim diameter.

Carriage and wagon tyres 3/64″ to 5/64″ according to type of wheel. Both tyring and untyring furnaces are gas fired by Bunsen burners fed from a booster pump supplying mixed gas and air under slight pressure. No welding at rim.

Southern Region.

Locomotives.

Tyres are finish bored with a fine feed at high speed using Tungsten carbide tools all sharp corners being removed. Shrinkage allowance varies from 1/800 to 1/1000 per inch of wheel center diameter, for tyres having retaining rings. For wheels having lipped tyres the shrinkage allowance is 1/1000 per inch of wheel centre diameter.

Tyres are heated evenly by Selas Air-Gas Equipment on a horizontal rotating table. No welding is used to prevent loose tyres.

Carriages, wagons and electric stock.

« Gibson » Ring Tyre Fastenings.

Latterly an alternative has been used to a limited extent wherein the ring is been dispensed with.

The wheel centre, in additon to shrinkage, is held in recessed tyres with lips on each side of the wheel centre.

Do not weld. Machine finish for inside of tyres and rims of wheel centres :

11.1 revolutions per minute with feed 0.018″. Tyres heated in gas ring furnace.

	Shrinkage allowance
Carriage wheel centres 3 ft. 1 in. diameter	0.0463″
Wagon wheel centres 2 ft. 9 ins. diameter	0.0625″

London Transport Executive.

Precautions are taken against loose tyres by using rivets or a « Gibson » retaining ring. All the more modern wheels are of the latter type. Tyres are bored with Tungsten carbide tipped tools and have a smooth finish. A shrinkage allowance of between .0012″ and .0014″ per inch. of centre diameter is made according to the type of wheel.

Centre diameters vary between 24″ and 37″. For the purpose of mounting, the tyres are heated on an induction heater (the tyre acting as a short circuited secondary of a transformer) to a temperature of approx. 240° C. No welding is allowed on tyres except as an emergency measure in cases of breakdown because of the effect the high temperature would have on the heat treated steel. In some cases the additional precaution was adopted of fitting studs radially through the rim of the centre into the tyre to prevent loose tyres. This practice has been discontinued without adverse result.

Victorian Railways, Australia.

Steam locomotives.

Tyres are secured to wheel centres by set screws or retaining rings of rectangular section welded after fitting into position with 4 welds at 90° apart 3/16″ fillet 3″ long on wheel centre.

Electric locomotives, rails cars, electric motor coaches, cars and wagons.

Tyres are secured by rectangular retaining rings of mild steel 7/8″ × 1/2″ or 7/8″ × 7/16″. The rings in one piece are pulled into place while the tyre is still hot and the lip of the tyre is then rolled into position under a special hydraulic press.

All types of rolling stock.

The bore of each tyre must be a good smooth finish.

Tyres are in general supplied by manufacturer, finish machined all over. After assembly on wheel centres contour is skimmed over in the lathe.

Shrinkage allowances are based on the diameters of the wheel centres of cast steel and mild steel disc plate type as follows : 1/750 for locomotive, car and wagon wheel cast steel spoke wheel centres and for rail motor cast steel spoke wheel centres with thick rims and tyres.

1/1200 for rail motor cast steel spoke wheel centres with thin rims or with narrow rims.

1/1500 for rail motors cast steel disc wheel centres with narrow rims.

1/1700 for rail motors mild steel disc plate wheel centres.

The tolerances are based on the diameters of the wheel centres as follows :

.003″ for 10″ to 30″ wheel centres.
.004″ for over 30″ to 45″ wheel centres.
.006″ for over 45″ to 60″ wheel centres.
.007″ for over 60″ to 70″ wheel centres.

Example. (Steam locomotives).

Tyre diameter inches		Wheel centre diameter ins.	Shrinkage inch.
Over tread	Internal		
72-15/16	66.688 max. 66.681 min.	66.777 max. 66.770 min.	.089
36-1/4	30.938 max. 30.934 min.	30.979 max. 30.975 min.	.041

Tyres are heated uniformly to a temperature not exceeding 450° C. The wheel centre is placed in the tyre and the tyre

is cooled off uniformly. Heating of small tyres is done on a coke fire. Oil burning jets are used for the large diameter locomotive tyres. Welding at the rim to prevent loosening of the tyre is not permitted. The welding of tyres is absolutely forbidden under any circumstances.

Ceylon Railways.

Periodical check for slackness in service. Rough on rail tread and smooth on flange corners, etc. Allowance for shrinkage of tyres approximately 1/800 part of diameter of wheel centre for 2′—0″ diameter and over :

1/700 for 1′—6″ diameter up to 2′—0″ diameter and 1/600 for 1′—0″ diameter up to 1′—6″ diameter. Tyres are electrically heated and shrunk on. Rims are not welded.

Pennsylvania Railroad Co., U. S. A.

Tyres shrunk on the wheel centres by heating the tyre. Wheel centres and tyre bores machined to a smooth finish and the cold tyre bore is 0.012″ to 0.016″ smaller per foot of wheel diameter than the wheel centre. Gas burning (or oil) heaters, curved to fit the tyre, are used to heat the entire circumference of the tyre. Do not weld the wheel rim but provide an extended plate riveted to the rim which engages a groove in the tyre to prevent lateral shifting of the tyre on the wheel in the event of its becoming loose.

Sudan Railways.

Locomotive, carriage and wagon.

(*a*) No specific machine feed is laid down but produce a normal good surface when turning up. Do not turn up all rims on retyring. Skim up when 0.020″ oval or taper for carriage and wagon and carrying wheels of locomotives and 0.030″ for locomotive coupled wheel rims.

(*b*) Shrinkage fits laid down and worked to are :

Loco : 48″ rim = 0.075″ carriage and wagon 0.001″ per 1″ of rim.

Loco : 56 1/2″ rim = 0.088″ diameter
Loco : 28 1/2″ rim = 0.035″.

(*c*) Producer gas fired.

(*d*) Do not weld the rims on any account.

Indian Government Railways.

For carriage and wagon stock tyre shrunk on and secured by glut-ring. For locomotives lip type tyres shrunk on and side riveted; experience shows these designs minimise the risk of loose tyres.

The wheel centre and tyre bore is fine machine finished with an interference of 1 thou. per inch diameter. The tyre heated by a gas ring to approx. 455° C before shrinking on to centre.

New Zealand Government Railways.

Locomotives and other rolling stock.

No deep tool marks are to be left on the mating surfaces. Shrinkage allowance is .001 inch per inch diameter of wheel centre. Tyres are heated electrically by induction. Forced cooling is prohibited. The temperature must not exceed 400°F as indicated by the fusing of specially prepared lead alloy pellets.

Welding on tyres is not permitted.

Retaining rings have been adopted in place of set screws to reduce risk of fracture.

South African Railways and Harbours.

Mating surfaces machined medium finish approximately 3/32″ feed.

Shrinking allowance 1/64″ per foot of internal diameter of tyre.

Tyres usually heated on ring fires. Electric tyre heaters have been employed with varying results.

No welding permitted on tyres.

Tyres secured to wheel centre by Gibson ring fastening.

QUESTION 17.

What are your specifications regarding the minimum thickness of tyres according to the load or maximum speed permitted for vehicles (minima both after repair and in service)?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

The minimum thickness of tyres permitted for locomotives on different classes of duty are as under :

Class of engine duty	Last turning thickness on tread	Scrapping thickness on tread
Express passenger . .	1.7/8″	1.3/4″
Ordinary passenger mixed traffic and goods tender engines, with wheels over 5′—0″ diameter (with tyres)	1.3/4″	1.1/2″
Goods tender engines up to 5′—0″ diameter (with tyres) . .	1.5/8″	1.3/8″
Goods tank engines .	1.9/16″	1.5/16″

Coaching stock.

Minimum thickness of tread after turning.

Class « A » stock (fast service) special vehicles e. g., diners, kitchens, sleepers, buffets, post office cars, etc., including milk tanks and road railers : 1.1/2″.

Other carriage stock : 1.1/4″.

Tyres under these thicknesses may be used on 4 or 6 wheeled carriage stock other than milk tanks or road railers until they reach the scrapping thickness of 1″.

Wagons.

Minimum thickness of tyres conforms to Railway Clearing House Regulations (British Railways') as under :

8, 10, 12 and 13 ton ordinary and 10 ton wagons with tyres secured in accordance with standard drawings. : 15/16″.

All other wagons : 1.1/4″.

Minimum thickness of flange : 7/8″ at 9/16″ from toe of flange.

Minimum width of tyre : 4.7/8″.

Tyres may be turned to within 1/16″ of minimum thickness of flange provided that the standard profile on the tread side of flange is maintained and that the diameters of wheels on the same axle are identical.

Eastern and North Eastern Regions.

Locomotives, steam, diesel, coaches and electric stock.

	Actual load at rail	Thickness at centre of tread
Grade 1. Wheels 6′-0″ tread dia. and over.	22 and over	2.1/8″
Grade 2. Wheels 6′-0″ tread dia. and over	18/22	2″
Grade 3. Class A5.A8. K2, K3, L1, N1, N2, V1, V3 and EM 1.	—	1.7/8″
Coupled wheels 5′-0″ tread dia. and over (not included in grades 1 and 2)	17 and over	1.3/4″
Grade 4. Classes B12, D3, G5, J26, J27, Q5 and Q6	—	1.3/4″
All other coupled and driving wheels . . .	—	1.1/2″
All carrying wheels. .	—	1.1/2″
Grade 5. Dock engines and sentinel engines .	—	1.3/8″
Tenders.		
5 000 gallon tender wheels (W. 1 and Pacific locos)	—	2″
All other tender wheels.	—	1.1/2″
Coaching stock.		
Wheels with journals 4.3/4″ dia. and over.	—	1.1/2″
Wheels with journals under 4 3/4″ dia./ 4.3/8″ (31 tons and over)	—	1.3/8″
Wheels with journals under 4 3/4″ dia./ 4 3/8″ (under 31 t).	—	1.1/4″
Wheels with journals under 4 3/8″ dia./ 3 7/8″.	—	1.1/4″

	Actual load at rail	Thickness at centre of tread
Wheels with journals under 3.7/8″	—	1.1/8″
4 and 6 wheeled passenger and non-passenger stock	—	1.1/8″
Electric stock motor coaches	—	1.1/2″
Electric stock trailer coaches	—	1.3/8″

Wagons.

	Thickness at centre of tread
Under 15 tons load	1.1/16″
Over 15 tons load	1.5/16″
Goods brake vans	1.3/8″

Note. — No tyre to be retained if it will not turn up to the thickness given above. Scrapped in service at discretion of examiners.

Western Region.

Engine tyres are allowed to run to a minimum thickness of from 1.1/2″ to 2″ according to type of engine.

At least 1/8″ of wear to be left on tyre after repair in shops.

Carriage tyres are allowed to wear to a minimum thickness of 1.1/4″ on tread irrespective of type of vehicle or maximum speed.

At the last turning the tread must be 1/8″ thicker than the minimum dimension.

Southern Region.

Locomotives.

Minimum thickness of tyres is not specified in relation to loads or speeds.

For tyres 6′—0″ diameter and over on tread the last turning size is 1.7/8″ and scrapping size 1.3/4″.

For tyres under 6′—0″ diameter on tread the last turning size is 1.5/8″ and scrapping size 1.1/2″.

	Thickness	
	Last turning	Scrapping
Carriages	1.1/8″	1″
Electric stock motor bogie wheels	1.1/4″	1.1/8″
Wagons	1.1/4″	1.1/8″ over 13 tons load
	1.1/8″	15/16″ under 13 tons load

London Transport Executive.

The minimum tyre thickness in service varies between 1.1/4 and 1.1/8 ins. according to the type of wheel, the minimum thickness after repair is 1/8″ greater.

These sizes have been arrived at from service experience.

Victorian Railways, Australia.

Condemning tyre thickness limits generally conform with the locomotive cyclopedia of American Practice 7th edition, p.1020. fig. 7. The dimension however has been influenced by such factors as defects occurring in service type of tyre fastening, depth of retaining ring groove, etc.

Ceylon Railways.

Carriages and wagon 1.5/16″ ex shops and condemning thickness 1.1/4″. Condemning thicknesses are fixed at these limits

on account of set screw fastened tyres. Lower figures worked to during war period

Pennsylvania Railroad Co., U. S. A.

Minimum tyre thickness road limit 2—1/4″ for modern road locomotives and 1—5/8″ for shifting locomotives. The shop tyre thickness limit after last turning, must be at least 1/4″ greater than the road limit. The thickness is independent of speed.

Sudan Railways.

No distinction is made in tyre scrapping sizes and loads carried or speeds run. The scrapping and « let-go » sizes are :

Locomotives coupled (all sizes) : 1.7/16″ let go; 1.1/4″ scrap.

Locomotive carrying and tender : 1.3/16″ let go; 1″ scrap.

Carriage and wagon disc wheels : 1″ let go; 7/8″ scrap.

Carriage and wagon spoke wheels : 1.1/16″ let go; 15/16″ scrap.

Indian Government Railways.

The maximum and minimum thickness of tyres for 5′—6″ gauge are stated below :

	New	Condemning	
		coupled wheels	carrying wheels
Locomotives	3″	1.1/2″	1.1/8″
Carriages and wagons	2 1/2″	—	1.1/8″

The minimum thickness of tyres for stock leaving shops 1/8″ above condemning size. No special provision made to limit axle loads or speeds in relation to tyre thickness.

New Zealand Government Railways.

Steam locomotives and other stock as described in table. (Loco. Code No. 15.)

Stock Group No.	Position of type	Dimensions				
		Minimum			Maximum	
		«A»	«B»	«C»	«D»	«E»
1	Locomotive leading bogies	1 3/4″	1 1/8″	3/8″	1/4″	1.5/16″
2	Locomotive drivers	1 1/2″	1 1/4″	3/4″	1/4″	1.5/16″
3	Locomotive drivers	1 5/8″	1 3/8″	3/4″	1/4″	1.5/16″
4	Locomotive trailing bogies	1 3/8″	1 1/8″	3/4″	1/4″	1.5/16″
5	Locomotive trailing bogies	1 1/2″	1 1/4″	3/4″	1/4″	1.5/16″
6	Locomotive tender bogies	1 3/8″	1 1/8″	3/4″	1/4″	1.5/16″
7	Electric locomotive bogies	1 3/8″	1 1/8″	3/4″	1/4″	1.5/16″
8	Electric locomotive drivers	1 1/2″	1 1/4″	3/4″	1/4″	1.5/16″
9	Multiple unit coaches	1 1/2″	1 1/4″	3/4″	1/4″	1.5/16″
10	Cars and vans, etc.	1 3/8″	1 1/4″	3/4″	1/8″	1.3/16″
11	Cars and vans, etc.	1 3/8″	1 1/4″	5/8″	1/8″	1.3/16″
12	Cars and vans, etc.	1″	3/4″	5/8″	1/4″	1.5/16″

Dimension — « A » minimum thickness of tread at last turning up.

Dimension — « B » minimum thickness of tread allowed to run.

Dimension — « C » minimum thickness of flange allowed to run.

Dimension — « D » maximum permissible hollowing in tyre allowed to run.

Dimension — « E » maximum depth of flange allowed to run.

NOTE. — Re-turning of worn tyres.

Workshops *are not* to turn worn tyres

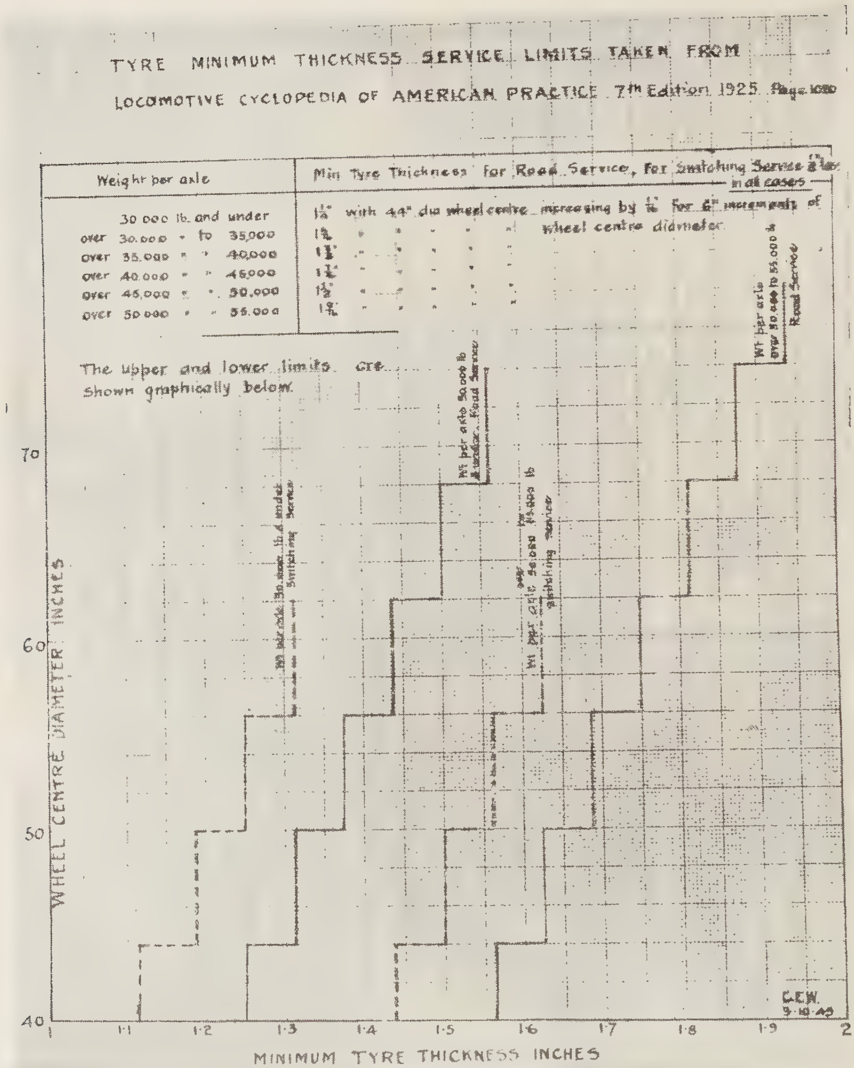


Fig. 7. — Minimum tyre thickness. *(Victorian Railways, Australia).*

unnecessarily, and for guidance it must be noted that *no tyres* must be returned if the hollowing *is less* than half of that indicated for the various dimensions in column « D », providing that the flange *is not* below contour «C », also that flats on the treads *do not* exceed that enumerated in clause 12 of code instruction No. 15.

Where the hollowing *is half*, or *more than half* than specified, *the tyre must be re-turned.*

Rail cars as described in table.

Stock Group No.	Description of stock	Dimensions A (see above)	B
2	49 seater rail cars — leading bogie	1 1/4″	1.5/32″
3	49 seater rail cars — rear wheels	1	29/32″
4	49 seater rail cars — rear wheels	1 1/4″	1.5/32″

South African Railways and Harbours

Standard minimum thicknesses at tread at last turning, based on axleload and experience, have been laid down for each class of engine — e. g. usual minimum thicknesses at last turning for tyres of main line engines and tenders as follows :

Engine coupled wheels : 1-5/8″.
Engine bogie wheels : 1-3/8″.
Tender wheels : 1-3/8″.

For carriage and wagon stock the minimum thicknesses are :

Coaching stock : 1-1/8″ to 1-1/4″; depending on size of axle.

Wagon stock : 1″ to 1-1/4″; depending on size of axle.

Motor coaches : 1-5/8″.

No limiting thickness in service is laid down directly but the maximum flange height is not permitted to exceed the nominal height by more than 1/4″ nor is the hollow wear on the tread permitted to exceed 1/4″. The final thickness of the tyre therefore cannot, in practice be less than the prescribed minimum thickness at last turning minus 1/4″.

QUESTION 18.

When wheels have flats do you repair by building up by welding and making good the tyre surface by grinding or turning?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives, and coaching stock.

No.

Eastern and North Eastern Regions.

Do not weld.

Steam locomotives.

Make good the surface by turning.

Electric motor coaches and carriages.

Make good the surface by turning where flats are of a depth of 3/32″ or more. Grind for minor flats.

Wagons.

Make good the surface by turning.

Western Region.

No.

Southern Region.

See answer to Question 12.

London Transport Executive.

No welding permitted. Where possible flats are turned out or in they are too deep, the wheel is re-tyred.

Victorian Railways, Australia.

A flat of 2 1/2″ long it must be taken out and returned. No welding permitted. (See Question 16.)

Ceylon Railways.

No — treads are turned down to new profiles.

Pennsylvania Railroad Co., U. S. A.

Flat spots are removed by turning. Tyres are not welded.

Sudan Railways.

We remove flats by turning only.

Indian Government Railways.

Wheels with flats re-profiled by turning.

New Zealand Government Railways.

Steam and electric locomotives. Multiple units and Rail Cars.

Welding not permitted. The tyres dressed to remove the flats and metal pick-up.

South African Railways and Harbours.

No. Welding on tyres is not permitted.

Wheels with excessive flats are removed from the vehicle and turned down to a smaller diameter.

QUESTION 19.

In addition to choice of metal and its treatment do you employ other methods to reduce tyre wear (e. g. lubricating flanges or rails)?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

Rail lubricators used, but put down primarily to reduce rail wear and only incidentally to reduce tyre wear.

Coaching stock.

No.

Eastern and North Eastern Regions.

No.

Western Region.

Flange oilers have been fitted to about 100 engines of the following classes :

Type	Coupled wheel diameters
2-6-2 T 2-8-0 T, 0-6-0 T 0-6-2 T	4′—7 1/2″
0-4-2 T	5′—2″
2-6-2 T	4′—1 1/2″

Normally fit either leading or trailing pairs of wheels, lack of space precludes from fitting both.

Oil reaches rails in sufficient quantity to reduce wear of tyres on other wheels not directly lubricated.

Southern Region.

Locomotives, carriages and wagons.

No. Where curves are severe and duty heavy lubricators are installed on the track.

London Transport Executive.

Wheel flange lubricators are fitted on the high side of the track 50 ft. prior to the start of a curve. For curves up to 250 yds long 2 lubricators are fitted and above this 3.

Check rail lubricators are fitted in a similar manner but on the low rail side.

Victorian Railways, Australia.

No. Tests made with flange lubricators on locomotives and electric suburban stock proved unsatisfactory.

Lubricators for oiling inner radii of rails are installed at certain curves with the object of reducing wear on rails.

Ceylon Railways.

Yes; on locomotive wheel flanges only on 5 chain curves.

Pennsylvania Railroad Co., U. S. A.

Do not use flange oilers on cars or locomotives.

Sudan Railways.

No such methods in use.

Indian Government Railways.

Depend on the metal and its treatment to obtain maximum life from a tyre. Flanges and rails not lubricated.

New Zealand Government Railways.

Steam and electric locomotives, multiple units, and rail cars.

No flange or rail lubricators or other devices used to reduce flange wear, except on the electrified tracks at Wellington.

South African Railways and Harbours.

Flange lubrication by water has been used but has been discontinued as it was expensive to maintain and was often not used by drivers. Rail greasers attached to the rails are at present preferred. Devices for attachment to the locomotive, are, however, still receiving consideration.

QUESTION 20.

Have you found with locomotives that the lateral displacement of the axles influences tyre wear?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

Taking for example a 4-6-0 locomotive :

Consider that an engine designed to negotiate severe curves, and called upon to do duty on a relatively straight track, the resultant effect upon wear of tyres would be greater. The following is a typical example of clearances provided between the tyre flanges and the rail for 4-6-0 locomotive :

Leading pair of wheels 7/16″ each side.
Intermediate pair wheels : 1/2″ each side. (thin flange).
Trailing pair wheels : 9/16″ each side.

In each case it is assumed that the rail gauge is 4′—8 1/2″.

Eastern and North Eastern Regions.

No comparative data.

Western Region.

Steam locomotives.

Assume lateral displacement is synonymous with total lateral clearances. The clearances of a given engine are intended to allow that engine to negotiate a given minimum curve, should the curve be sharper the greater must be the clearance and consequently the greater forces imposed by the rail on the wheels against the resistance offered by the springs, coupled rods, etc. Although clearances are sufficient to permit the negotiation of a sharp curve without danger of bending the frames or the derailment of the engine, expect wear on the flange of the tyres would be greater than in the case of an engine of the same class negotiating a curve of greater radius. Experience substantiates that, in the case of certain engines working on branch lines with sharp curves, which engines have proper clearances to negotiate these curves, give trouble through excessive tyre wear unless flanged oilers are fitted, (see Question C. 19 above). The total lateral coupled wheel clearances when new for 4-6-0 engines all types (wheel diameters from 3′—8″ to 6′—8 1/2″) are as follows :

Leading : 21/64″.
Driving : 27/64″.
Trailing : 21/64″.

Southern Region.

Steam locomotives.

No information, but experience has shown that the wear is greater on the wheels when engines of the same class are called upon to work over more tortuous track. Design allows for the curve, in conjunction with the wheelbase, to determine the amount of side play required at each axle; for example, a six-wheeled coupled engine, the leading and trailing wheels having normal tyre flanges, there is a clearance between rail and flange of 5/16″ each side. The driving wheels have a clearance of 7/16″ between flange and rail. There is in addition a play between the axlebox journals in the axle box and horns of 1/32″ in each case on each side thereby giving a total clearance of the leading and trailing wheels of 3/8″ and the driving wheels 1/2″. All tender wheels have similar flange and rail clearances, and lateral play as for the leading and trailing wheels of locomotives Provision for lateral displacement on centre pair of tender wheels provided for by sliding spring shoe on top of the axlebox.

London Transport Executive.

Not applicable.

Victorian Railways, Australia.

It is considered that excessive lateral clearance due to wear in boxes and horns reacts unfavourably on tyre flanges.

Ceylon Railways.

Yes.

Pennsylvania Railroad Co., U. S. A.

No data to show that lateral displacement of wheels influences tyre wear. It is a fact, however, that the longer rigid driving wheel base locomotives wear their front driving tyres at a greater rate than locomotives with a shorter wheel base.

Sudan Railways.

Think some extra wear does result from such conditions.

Indian Government Railways.

Reported that reduced lateral displacement of axles gives reduced tyre wear, no measurements to substantiate this report.

New Zealand Government Railways.

Steam locomotives.

Noticeable that the tyres of the long wheel base locomotives (8 coupled) show more flange wear than those of short wheel base locomotives (6 coupled). The amount of lateral displacement possible does not compensate for the added length of the rigid wheel base.

Electric locomotives, and multiple units.

Not investigated.

Rail cars.

The middle axle of the 6-wheeled Vulcan Railcars has wheels without flanges, no other lateral displacement provided.

South African Railways and Harbours.

In certain special instances it has been found that the provision of slight additional side play for the leading coupled wheels results in a more even distribution of flange wear between the leading and driving wheels.

QUESTION 21.

Have you proved that lessening of huntin (particularly lessening the rotation of th bogie round its pivot) reduces tyre wear?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

No reply.

Eastern and North Eastern Region

No data available.

Western Region.

No data available.

Southern Region.

No information.

London Transport Executive.

This has not been proved but it is believe that reduced hunting and nosing of whe and axle assembly and nosing of bogie c reduce tyre wear.

Victorian Railways, Australia.

It is considered that the introduction locomotive bogies and trailing trucks constant resistance rockers has resulted the reduction of flange wear. No restrai ing device for lessening the rotation of bog around its pivot has been tried.

Ceylon Railways.

No reply.

Pennsylvania Railroad Co., U. S.

No data to show that freely swivelli engine trucks affect the rate of tyre we

Sudan Railways.

Not proved.

Indian Government Railways.

That is our general observation, but this cannot be said to be « proved » owing to lack of measurements.

New Zealand Government Railways.

No information.

South African Railways and Harbours.

With steam locomotives hunting has not presented any problem. With two-bogie electric locomotives, prevention of hunting, in the form of rotation of the bogie about its pivot, has been found to be most important if excessive tyre wear is to be avoided.

QUESTION 22.

Have you tried or do you use independent wheels? What has been your experience with these wheels regarding tyre wear?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Coaching stock.

Experiments made with one vehicle. The trouble experienced with the independently rotating wheel nullified the experiment.

Method employed was to use a normal type of axle with a standard fixed wheel at one end : at the other end the wheel was mounted on the axle by a bearing allowing relative rotation. The main reasons for closing the experiment were as follows :

1) Difficulty in maintaining satisfactory lubrication on main bearing; two separate attempts were made to achieve this.

2) Increased flange wear on tyres.

3) No definite reduction of tractive resistance.

4) The increased liability of wheel pick-up during braking.

Eastern and North Eastern Regions.

No.

Western Region.

No.

Southern Region.

No.

London Transport Executive.

No.

Victorian Railways, Australia.

No.

Ceylon Railways.

No reply.

Pennsylvania Railroad Co., U. S. A.

Do not use independent wheels unless this is meant to signify wheels with unflanged tyres. Wheels with unflanged tyres are used to increase the life of driving box hub liners and permits locomotives with longer rigid driving wheel bases to be operated on sharp curves.

Sudan Railways.

No.

Indian Government Railways.

No.

New Zealand Government Railways.

Rail cars.

The middle axle of the 6 wheeled Vulcan rail cars has independent wheels because the axle has a set in it to clear the engine. The tyre wear is normal.

South African Railways and Harbours.

Independent wheels have not been tried.

D. AXLE BOXES.

a) Roller bearing boxes.

QUESTION 23.

Do you use Roller bearings? If so, kindly say what results have been obtained regarding :

1. *Number of hot boxes.*
2. *Maintenance costs.*
3. *State period between lubrication and inspection.*

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

Yes, to a small extent on locomotives.

(1) No hot boxes have occured to date. Some of these boxes have run for nearly a million miles.

(2) True costs of maintenance not available for earlier applications, but with more recent applications, maintenance is confined to examination and lubrication at periodic mileages. It is anticipated that the cost of this will be in the region of £ 10 per axle per 1 000 000 miles.

(3) Generally speaking on oil lubricated boxes, lubrication is carried out every 10 — 12 000 miles. On grease lubricated boxes this is every 6 months. Examination of the bearings takes place at every shop repair which may be from 70 000 to 100 000 miles.

Electric motor coaches.

Yes.

(1) None.

(2) No record.

(3) Liverpool/Southport saloon stock. — Inspected at wheel turning. Oiled every 25 days.
Wirral stock. — Greased at wheel turning.
Euston/Watford compartment stock. — Greased at wheel turning.

Eastern and North Eastern Regions

Steam locomotives.

Yes, but not sufficient to give particulars

Electric motor coaches.

Two twin sets fitted with Hoffmann roller bearings.

Carriages.

One sleeping car fitted with six-wheeled bogies and Timken bearings.

Wagons.

No.

Western Region.

No.

Southern Region.

None in use.

London Transport Executive.

(1) The failure rate of roller bearing axle boxes in service over the last 10 year causing a delay of 2 mins. or greater is .00046 per 100 000 miles per box/yea = .0014 per 500 000 K. M. per box year.

(2) The annual maintenance costs ar estimated to be 4.24/— per roller bearin and 36.9/— per journal bearing.

(3) Lubrication is carried out every 1 weeks with grease.

Victorian Railways, Australia.

Steam locomotives.

Applied to certain locomotives for engin bogie, trailing truck and tender.

(1) No hot boxes recorded.

(2) A considerable reduction of mainte ance costs is achieved as compared wi existing type bearings.

(3) SKF bearings.
(*a*) Engine bogie. Grease added each 12 000 miles, outer rin rotated 120° at 162 000 miles, stri ped and examined at 500 000 mil (See note below).
(*b*) Trailing truck and tender bog Grease added at 192 000 miles out

rings rotated 120° at 216 000 miles, stripped and examined at 500 000 miles. (See note below.)

(c) Tender bogie. Grease added at 250 000 miles. Outer rings rotated 120° at 358 000 miles, stripped and examined at 500 000 miles.

Timken bearings.

Cups rotated 120° and re-oiled at 250,000 miles. Stripped and examined at 500,000 miles. (See note below.)

Complete installation of SKF journal side bearings is to be adopted on the latest express passenger locomotives.

Electric locomotives.

No.

Rail cars.

Yes.

(1) No hot boxes recorded.

(2) No data available.

(3) Not yet determined.

Electric motor coaches.

No.

Carriages.

Roller bearings are used throughout on the « Spirit of Progress », Sydney Express Train and similar steel cars and vans for country service.

(1) No hot boxes recorded.

(2) Maintenance work practically eliminated for the life of the bearing.

(3) Oil is completely cleaned out of box at each 12 months running period or approx. 140 000 miles. Stripped and examined, cups turned at each period of 300 000 miles. Bearings removed from service at 1 200 000 miles.

Wagons.

No.

Note : SKF outer rings are subsequently rotated 120° at increments of 108 000 miles. Timken cups are subsequently rotated 120° at increments of 216 000 miles.

Ceylon Railways.

Experimental stage. — Satisfactory. — Periodical inspection 6 monthly period.

(1) Nil.

(2) Satisfactory.

(3) Periodical inspection half yearly.

Pennsylvania Railroad Co., U. S. A.

Roller bearings are used extensively on locomotive driving wheels, engine trucks, and trailer truck wheels and tenders. They result in decreased hot boxes, and maintenance costs. Oil level in the locomotive boxes is checked every 30 days at monthly boiler wash and lubrication is replenished as required. Boxes are inspected after each trip to detect abnormal running temperatures, oil leaks or defective parts.

Sudan Railways.

Yes, on carriages bogies only, 120 boxes only. Roller bearing boxes have not been successful and are not being repeated on account of exceptional conditions.

(1) Practicaly unknown.

(2) No separate figures are available.

(3) Every 6 months the box is opened and if necessary more grease is added.

Indian Government Railways.

Roller bearings standard for carrying wheels on locomotives. Have 500 boxes in use on coaching stock for some years with satisfactory results. Reliable data in regard to hot boxes not available; there have been very few such cases, also maintenance costs low. Manufacturers' recommend ations strictly followed in respect of lubrication and inspection.

New Zealand Government Railways.

All classes of rolling stock (wagons other than bogie vehicles not included).

Yes.

(1) No hot boxes, excepting for occasional failures where used for steam locomo-

tives, due to the fracture of rollers or races.

(2) Statistics respecting maintenance cost not kept, but costs are low.

(3) *Steam and electric locomotives and multiple units.*

Inside journal axleboxes on pony axles and bogies, including those on coupled wheels, have grease supply replenished every 3 months. Timken oil lubricated roller bearings for locomotives have oil replenished at each shopping, one month following this and then after every 6 months, to next shopping. Inspected each shopping and after derailment. Electric locomotives and multiple units go from overhaul to overhaul.

Rail cars.

Lubrication inspection takes place at tyre turning only i. e. 50 000 to 90 000 miles.

Coaching stock and bogie wagons.

S. K. F. grease lubricated bearings are inspected and receive necessary attention during heavy overhauls. Timken oil lubricated bearings receive attention as follows :

1. At workshops.
2. Then 1 month after release from workshops.
3. Then 7 months after release from workshops.
4. Thereafter at 6 monthly intervals.

South African Railways and Harbours.

Yes.

1. With self aligning barrel roller bearings a comparatively large number of hot boxes has been experienced — an average of 10 % per year of the total number in service. This, however, was mainly due to the poor qualities of lubricants. The type with tapered roller bearings give very little trouble, hot boxes experienced beinge only about ½ % of the total number in service.
2. Cost of lubricating roller bearings :
   Self-aligning barrel roller bearing — 7/— per box per annum.
   Tapered roller bearings — 2/4 d per box per annum.
3. Roller bearings are examined after the first month in service thereafter every three months and replenished with grease or oil when necessary.
   Roller bearings are dismantled, washed out and thoroughly inspected when locomotives and passenger coaches are sent to workshops for overhaul, viz.
   Locomotives approximately every 3 years (150,000 miles).
   Passenger coaches approximately every 3 years.

QUESTION 24.

Have you found any difficulties due to the use of axleboxes of this type? Please indicate (fractures and wear of details, damage through rough shunting, etc.).

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

No difficulties experienced to date.

Eastern and North Eastern Regions.

Steam locomotives. Electric motor coaches and carriages.

No.

Western Region.

See reply to Question 23.

Southern Region.

See reply to Question 23.

London Transport Executive.

No difficulties are encountered with the design of axlebox used. Renewable manganese steel liners are provided engaging the bogie horn checks which are similarly equipped. The hole in the axlebox lid which carries the thrust pad equipment is fitted with a renewable steel bush. The axleboxes are of cast steel and fractures do not occur.

Victorian Railways, Australia.

No.

Ceylon Railways.

One case of loose sleeve resulting in a scoured journal.

Pennsylvania Railroad Co., U. S. A.

No difficulties have been experienced.

Sudan Railways.

No.

Indian Government Railways.

No.

New Zealand Government Railways.

Steam locomotives.

The loss of grease from cannon boxes is greater than expected. There have been a few cases of fracture of rollers and races. Water and filth was forced into the bearings of the bogies by high pressure cleaning guns.

Other rolling stock.

No.

South African Railways and Harbours.

The main difficulties experienced with roller bearings on carriages, wagons, steam and electric locomotives are the result of poor qualities of lubricants particularly in respect of grease which is found to break down at ordinary running temperatures.

During periodical examination, roller bearings are frequently found to be slightly pitted or flaked and it is the practice to replace these bearings to obviate any possibility of a later failure in traffic.

QUESTION 25.

What type of roller bearing box do you use (cylindrical, conical or roller bearing)?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

Bearings used mainly Timken tapered, but also applications of Skefko spherical and Hoffmann cylindrical types.

Electric motor coaches.

Timken taper — 512.
SKF parallel — 152.
SKF self-aligning — 48.

Eastern and North Eastern Regions.

For examples of applications to steam locomotives, electric stock and carriages, see Fig. 8. Locomotive crank axle (Timken).

See Fig. 9. Locomotive bogie axle (Timken).

See Fig. 10. 4-wheeled motor bogie (Hoffmann).

Western Region.

See reply to Question 23.

Southern Region.

See reply to Question 23.

London Transport Executive.

Fig. 11 shows the general arrangment and principal dimensions of a typical roller bearing axlebox in service. The maximum load per *axle* for a box of this type is about 14 tons.

Victorian Railways, Australia.

Steam locomotives.

SKF spherical roller bearings for railway axlebox.

Timken tapered dual row roller bearings.

Rail cars.

Walker Diesel rail cars use Timken tapered single row roller bearings, one pair per axlebox.

Carriages.

Timken tapered dual row roller bearings.

Ceylon Railways.

« Skefko » roller bearings and Hoffmann's ball and roller bearings.

Pennsylvania Railroad Co., U. S. A.

Tapered roller bearings, cylindrical roller bearings, and spherical roller bearings are used.

Sudan Railways.

Double row spherical roller bearing (2 races per box).

Indian Government Railways.

Both SKF (barrel-shaped rollers) and Timken (taper rollers) bearings employed on locomotives and coaching stock. Recently Hoffmann roller bearings added to the list of permissible alternatives.

New Zealand Government Railways.

Steam and electric locomotives, multiple units, rail cars, passenger and wagon stock.

Timken conical roller bearings and S. K. F. spherical roller bearings.

South African Railways and Harbours.

Roller bearings in use on steam and electric locomotives are of two types :

a) Tapered roller bearings.

b) Self-aligning barrel roller bearings.

For Carriage and Wagon Stock :

Roller bearings were fitted to a few short cattle wagons. As replacements become necessary plain bearings will be fitted.

Roller bearings of the following makes have been fitted to 1st and 2nd class main line coaches including motor coaches :

Timken : tapered roller.

Skefko : self-aligning barrel — majority with tapered sleeves.

Hoffmann : parallel roller with thrust bearing.

QUESTION 26.

What type of protection do you use against the penetration of dust and water into the interior of the box?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

Sealing rings provided with grooves and packed with stiff grease, in certain instances supplemented by leather seals.

Grease packed labyrinths. No special protection.

Eastern and North Eastern Regions.

See answer to Question 25.

Western Region.

See reply to Question 23.

Southern Region.

See reply to Question 23.

London Transport Executive.

See answer to Question 25.

Victorian Railways, Australia.

Steam locomotives.

SKF felt rings or sealing collars.

Timken labyrinth type enclosure.

Rail cars.

Timken enclosure sleeve.

Carriages.

Timken labyrinth type enclosure.

Ceylon Railways.

Axlebox makers designs.

Pennsylvania Railroad Co., U. S. A.

A labyrinthic seal is provided in the opening between axle and box to retain the lubrication and exclude dirt and moisture.

Sudan Railways.

Felt ring in back of box sealing against thrust ring on journal collar.

Indian Government Railways.

No special precautions other than those embodied in the manufacturer's designs adopted.

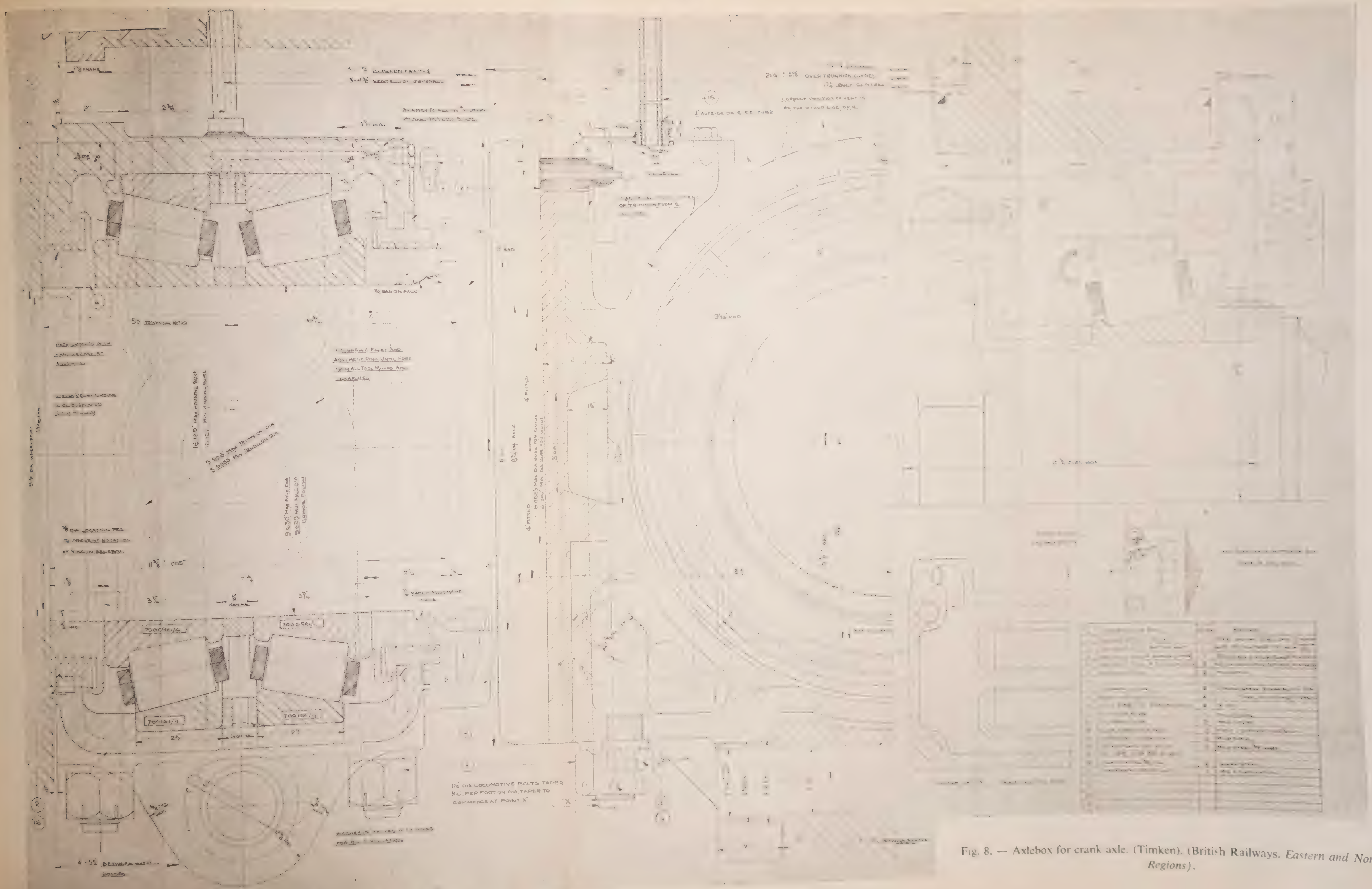
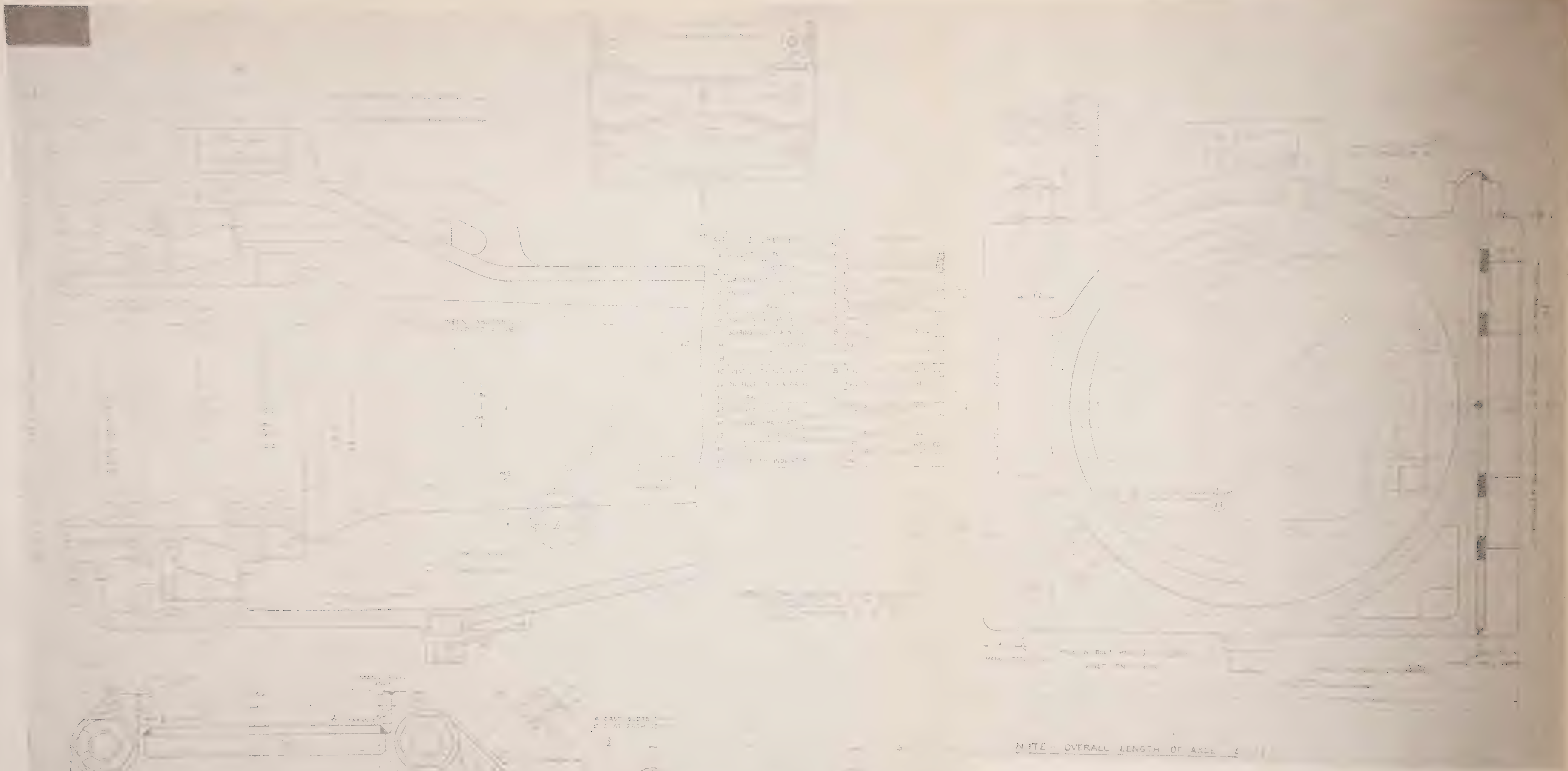


Fig. 8. — Axlebox for crank axle. (Timken). (British Railways. *Eastern and North Regions*).



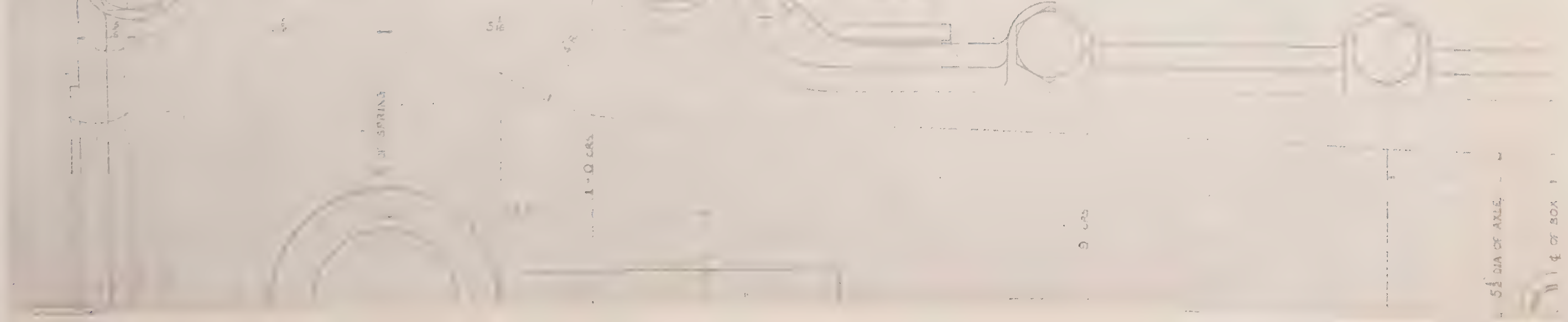


Fig. 9. — Locomotive bogie axlebox (Timken). (*British Railways. — Eastern and North Eastern Regions.*)

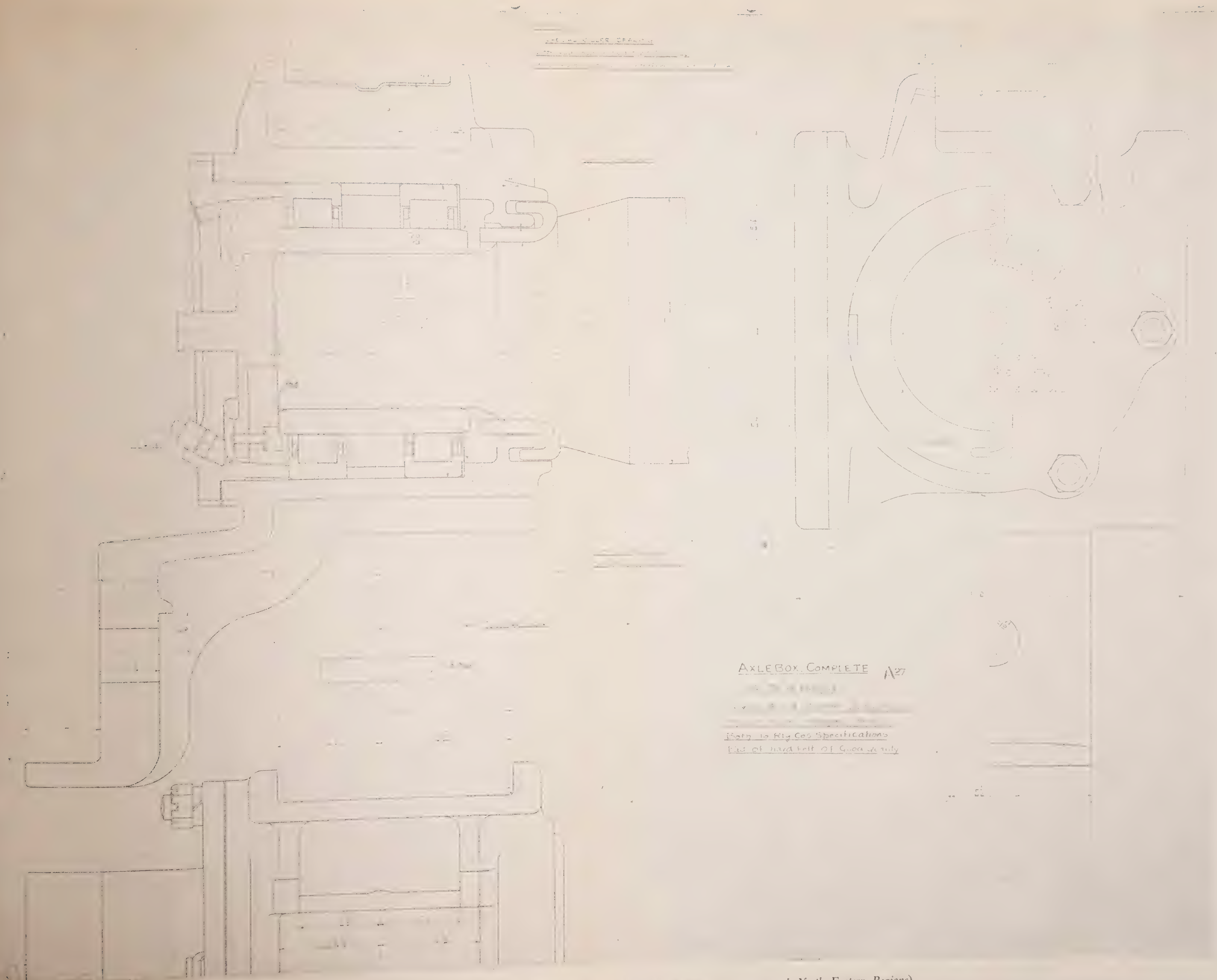
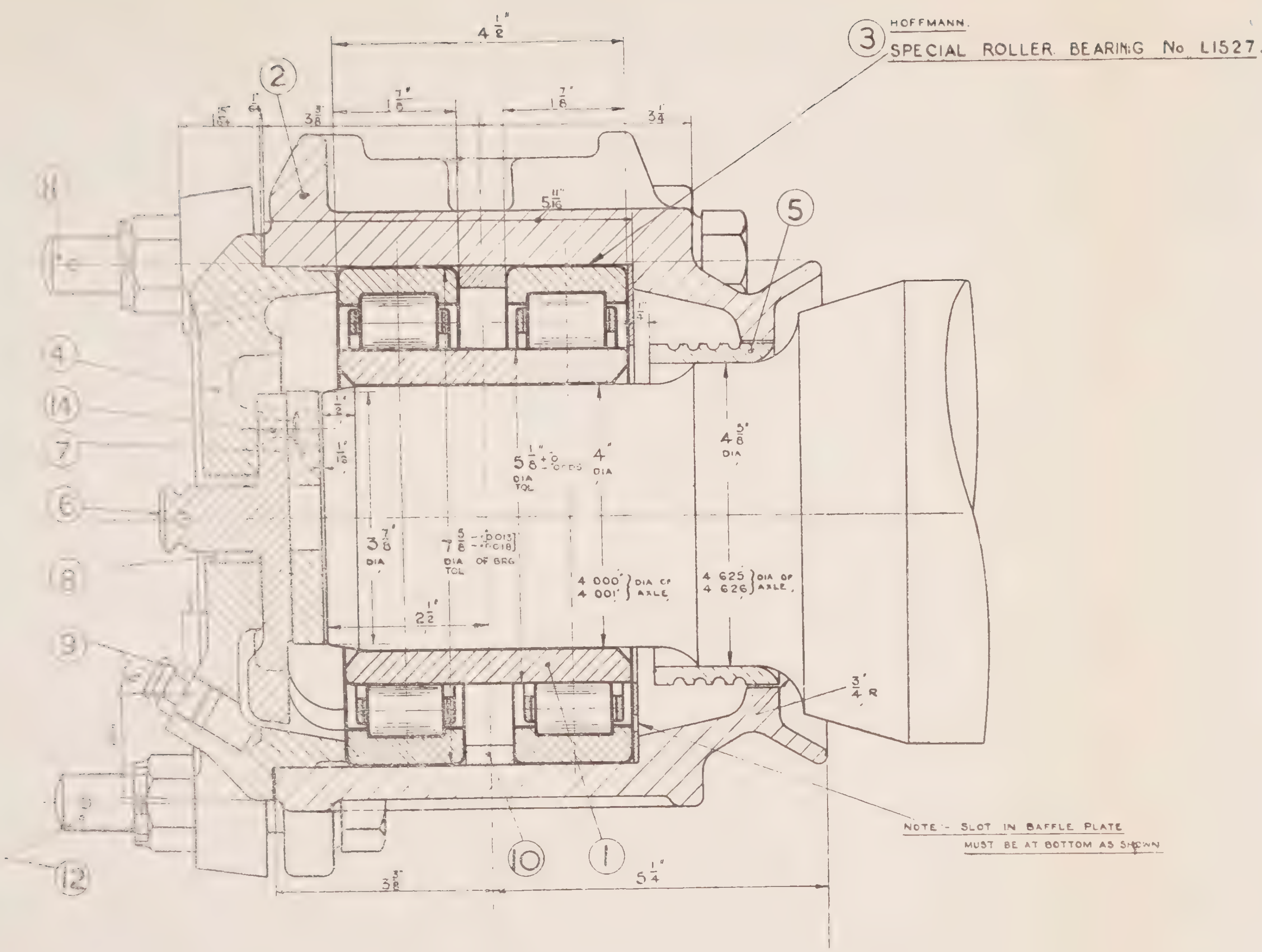
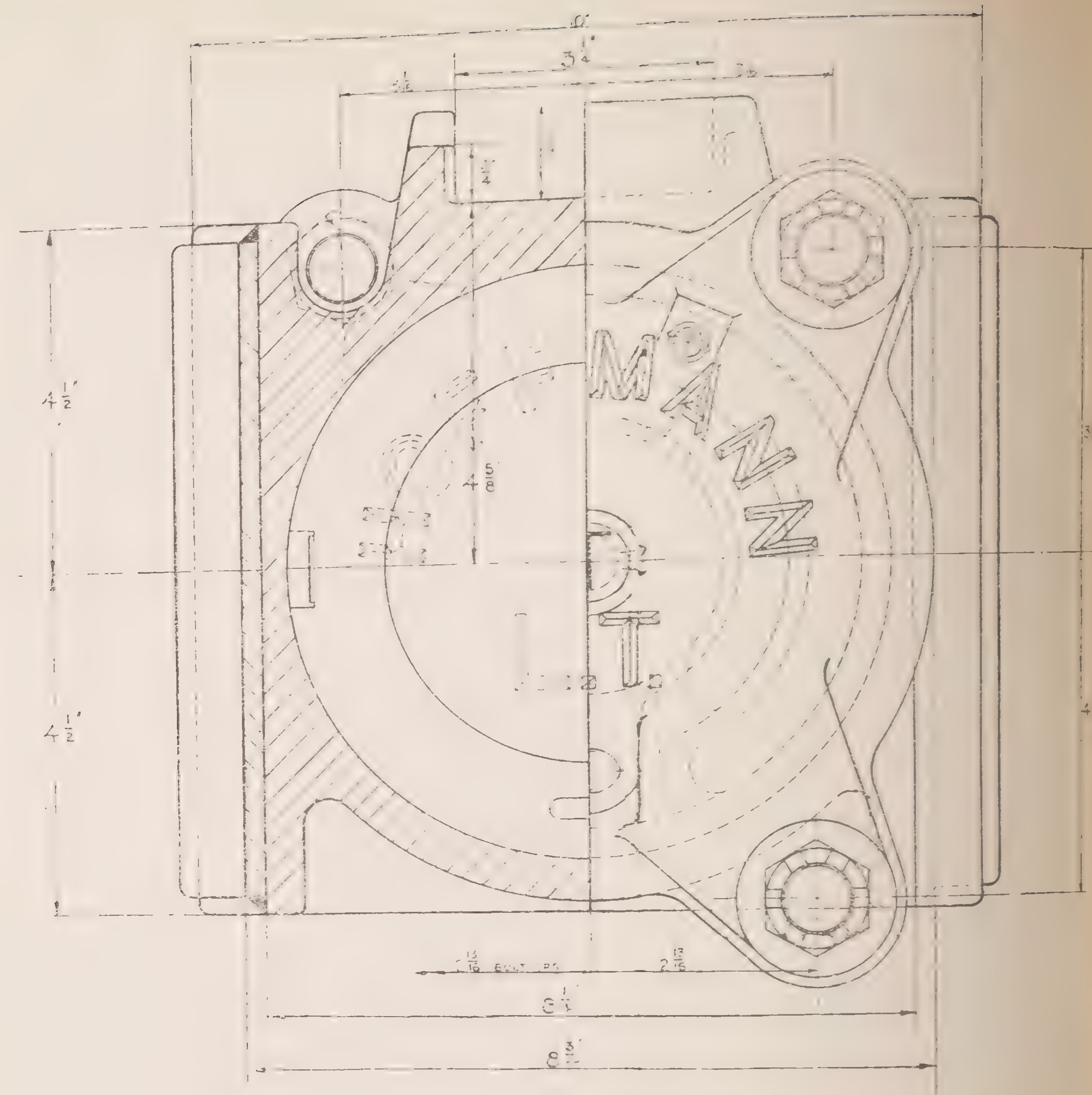


Fig. 10. — Electric motor bogie axlebox (Hoffmann). *(British Railways. — Eastern and North Eastern Regions)*





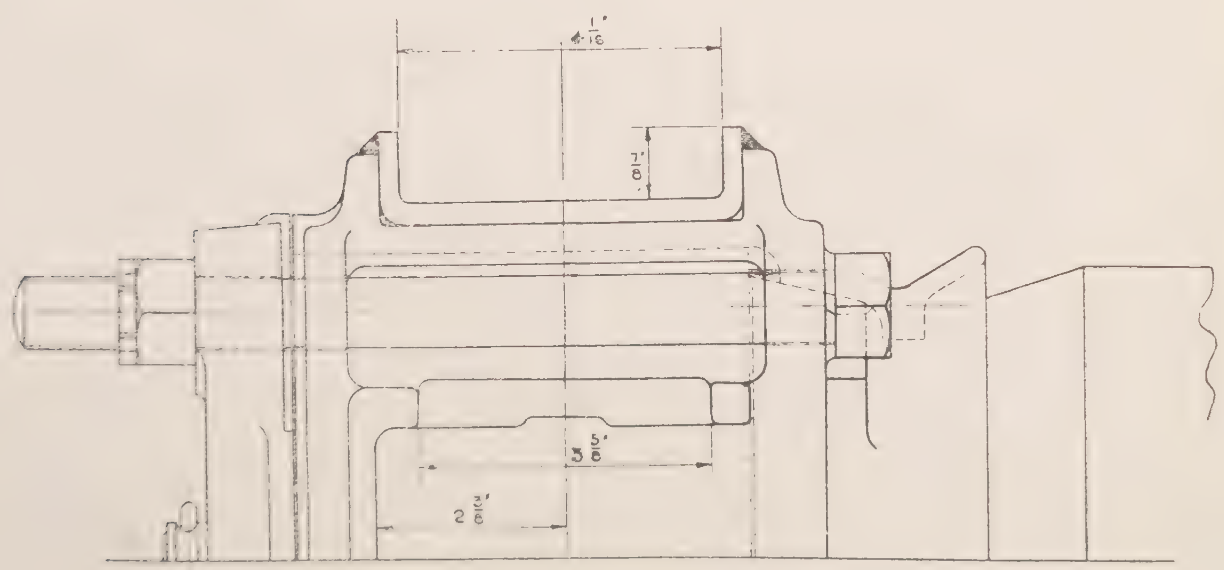


Fig. 11. — Roller Bearing axlebox (Hoffmann). *(London Passenger Transport).*

New Zealand Government Railways.

Steam and electric locomotives, multiple units, rail cars, passenger and wagon stock.

S. K. F. — Labyrinth filled with grease. Also felt rings in some boxes.

Timken. — Labyrinth. Leather shields fitted also.

South African Railways and Harbours.

Axleboxes of the tapered roller-bearing type are provided with oil slinger rings and labyrinth seals which are filled with hard water-pump grease.

Axleboxes of the self-aligning barrel roller-bearing type are provided with felt seals. In addition, the provision of a vent or breather pipe is usually requested.

QUESTION 27.

What are the loads per axle and the speeds permitted for the boxes you use? Give principal dimensions, catalogue number, drawing, etc.?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

	Load per axle		Designed speed. Miles per hour
	Tons	Cwts	
Express passenger. 4-6-2 Class 7 taken as typical.			
Bogie	10	18	—
Coupled wheels . .	22	14	—
Pony truck	16	10	—
Tender :			
Leader	19	8	100
Intermediate . .	18	10	—
Trailer	18	18	—

	Load per axle		Designed speed. Miles per hour.
	Tons	Cwts	
Mixed traffic. 4-6-0 Class 5 (Caprotti valve gear) taken as typical.			
Bogie	8	19	—
Coupled wheels :			
Leading	18	18	80
Driving.	19	0	—
Trailing	18	14	—
Tender :			
Leader	18	6	—
Intermediate . .	17	11	—
Trailer	17	19	—

Typical principal dimensions etc.

Timken. — Bogie : firm's Drg. RF. 7616/1. Double row, journal dia. 6 1/2″, journal length 11″.

Coupled : firm's Drg. RF 7633/1. Single row, journal dia. 9 1/4″, journal length 8 7/8″.

Tender : firm's Drg. RF. 7605/3. Double row, journal dia. 6″, journal length 8 9/16″.

Skefko. — Coupled : firm's Drg. 403228 Double row. journal dia. 260 mm length 10″.

Hoffmann. — Pony : double row and ball thrust. Journal dia. 5 1/2″—6″.

Electric motor coaches.

Liverpool/Southport Saloon Stock. — Timken taper: Drg. No. R.F. 5704/5. Max. load 13 1/2 tons/axle. Max. speed 70 miles per hour.

Wirral Stock. — SKF parallel Drg. Nos. 1.132748 and 1.132749. Max. load 13 tons /axle. Maximum speed 60 m. p. h.

Euston/Watfort Compartment Stock. — Timken taper Drg. No. D. 1904/3. SKF self-aligning Drg. No. 1.132300 and 1.130747 Max. load 16 tons/axle. Max. speed 60 m. p. h.

Eastern and North Eastern Regions.

	Railroad axle			Static load journal			Designed speed
	T.	C.	Q.	T.	C.	Q.	m.p.h.
Steam locomotives.							
Bogie	9	16	2	4	5	2	—
Coupled wheels (max.)	22	7	0	9	5	2	—
Pony truck	19	0	0	8	12	2	90
Tender	15	14	0	6	17	0	—
Electric coaching stock.							
Motor bogie	12	0	0	5	2	2	—
Articulated bogie	8	12	0	3	15	0	60
Trailer bogie	6	12	0	3	0	0	—
Carriages	7	13	3	3	5	0	90

Particulars of dimensions etc., of roller bearings are given on drawings supplied by Eastern and North Eastern Regions.

The carriage bearing figures are for the six-wheeled bogie vehicle.

London Transport Executive.

See answer to Question 25.

Victorian Railways, Australia.

Steam locomotives.

Maximum of 43 350 lbs. axle load on rails. Speed up to 70 miles per hour. SKF 1.37605, bore 5.1118″, O. S. Dia. 11.0238″ width 3.661″.

Timken EE 270 000, bore 5.375 max. o. s. dia. 11.0236″ max. width 6.75.

Rail cars.

Walker Diesel rail cars, 16 800 lbs. axle load on rails.

Speed 45 miles per hour.

Timken 938-932 : bore 4 500″, o. s. dia. 8 375″, max. width 2 625″.

Carriages.

Light type.

30 550 lbs. maximum axle load on rails Speed up to 70 m. p. h..

Timken EE 153000: bore 4 875″, o. s. dia. 10.1875″, max. width. 6.75″.

Heavy type.

31 700 lbs. maximum axle load on rails.

Speed up to 70 m. p. h.

Timken EE 270 000 series, bore 5 125″, o. s. dia. 11.0236″, max. width. 6.75″.

Ceylon Railways.

Loads and speeds are not limited by axleboxes in use.

Pennsylvania Railroad Co., U. S. A.

Loads per axle for our latest steam passenger locomotives are : engine truck — 53 650 lbs.; drivers — 69 250 lbs.; trailer — 65 000 lbs.

Passenger car loads with 6″ × 11″ size roller bearings average about 37 500 lbs per axle for sleeping cars, and slightly less for coaches.

For examples of applications to steam locomotives and passenger car bearings see Fig. 12 and 13.

Sudan Railways.

(*a*) SKF bearing SKF catalogue No 1.35156 — covers the general type.

(*b*) Journal size 110 m/ms. and 215 m/ms. but taper collars go on journal before the R. B. races.

(*c*) Axle loads vary between 7-8 tons. The question of speed limitation does not arise, speeds are low.

New Zealand Government Railways.

Steam locomotives.

Maximum permissible speed for express trains = 50 m. p. h.

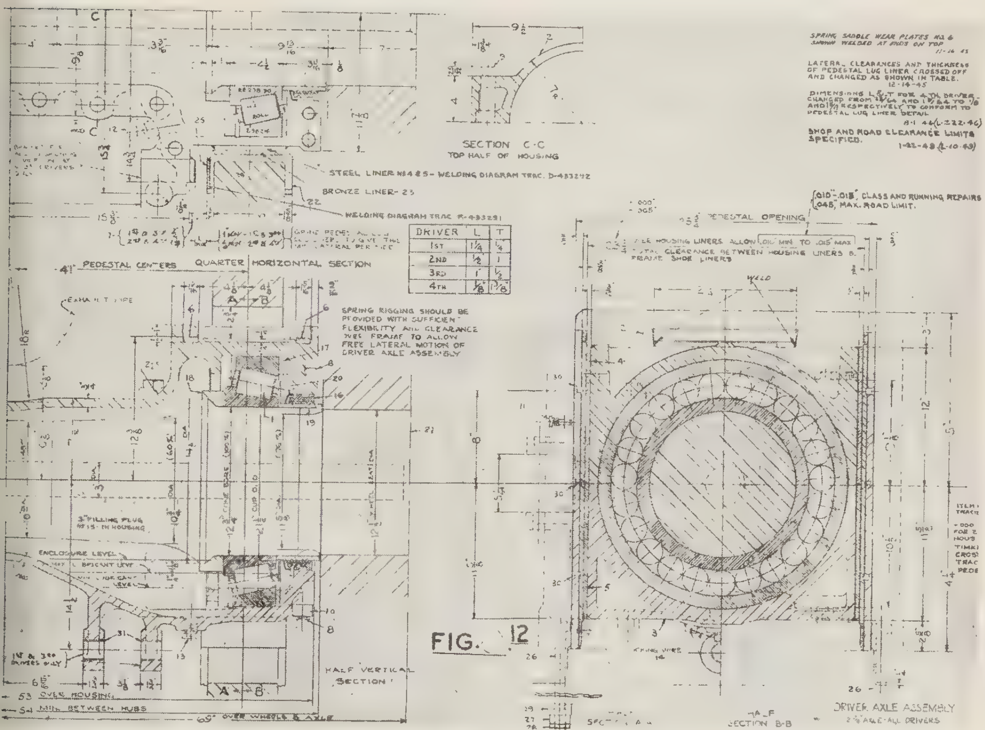


Fig. 12. — Locomotive driving axlebox (Timken). *(Pennsylvania Railroad Cy. — U. S. A.)*

Indian Government Railways.

The heaviest axle loads where roller bearings have been used in India are 18.75 tons for locomotives and 16 tons for coaching stock. Maximum permissible speed in India is 60/65 miles per hour, should not be taken to imply that the bearings are not suitable for higher speeds.

Electric locomotives.

Maximum safe speed 55 m. p. h. Maximum permissible speed 50 m. p. h.

Multiple units.

About 12 tons per axle, loaded. Max. safe speed 60 m. p. h. Maximum permissible speed 50 m. p. h.

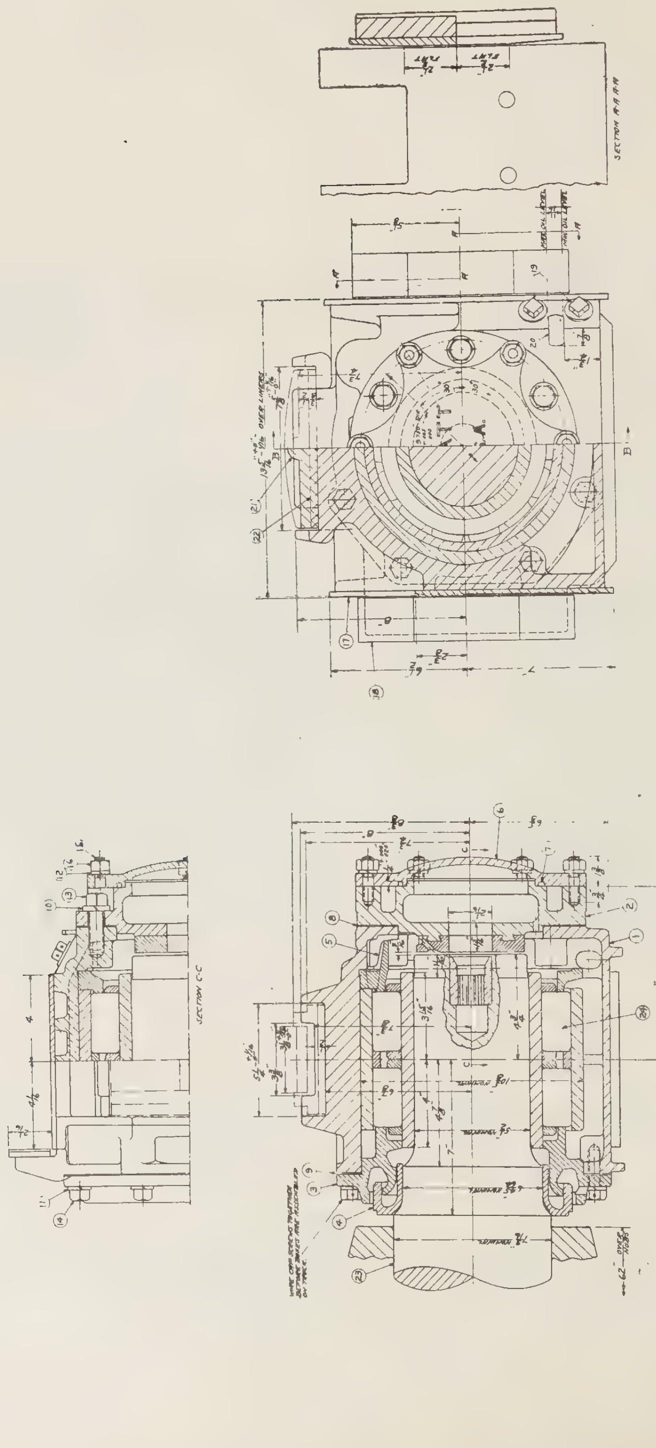


Fig. 13. — Passenger car axlebox (Hyatt). *(Pennsylvania Railroad Cy. — U. S. A.)*

Rail cars.

Maximum permissible speed 55 m. p. h.

Coaching and wagon stock.

Maximum speed 50 miles per hour.

South African Railways and Harbours.

Roller-bearing axleboxes carry loads as follows :

Steam locomotives.

Up to 19 tons per axle at speeds up to 60 miles per hour.

Electric locomotives.

Up to 20 tons per axle at speeds up to 60 miles per hour.

Carriage and wagon stock.

Up to 27 000 lbs. per axle at speeds up to 60 miles per hour.

QUESTION 28.

What is the system of mounting the rollers on the journal? What are the advantages and disadvantages of the system used?

REPLIES

BRITISH RAILWAYS

London Midland Region.

Steam locomotives.

In all types used, the inner roller races are mounted directly on the journal with a heavy press fit, spacers being employed in the double row Timken and Hoffmann applications.

This method is the simplest, lightest and most permanent method of assembly.

The disadvantage is that a press is needed to remove the bearing from the axle but, as the occasions for this are rare, it is not a serious one.

Electric motor coaches.

Timken taper : tapered sleeve between inner race and journal passed on.

SKF parallel : inner race shrunk on journal.

SKF self-aligning : tapered sleeve driven home between both inner and outer races and journal.

Eastern and North Eastern Regions.

Electric motor coaches and carriages.

Arranged as shown for accessibility. See answer to Question No. 25.

London Transport Executive.

The boxes are of the « pull-off » type which have the advantages of easy mounting and removal. The axle stub has a smooth surface, unrestricted by nuts and screw threads, for the application of the probes of an ultrasonic axle tester. The lateral forces imposed on the axle are transmitted to the axlebox by means of an end thrust pad.

It is necessary to provide adequate interference allowances between the axle journal and the shrunk fitted axlebox sleeve and to ensure that the quality of the machining of the axle journal and sleeve is in accordance with the specified requirements.

Victorian Railways, Australia.

Steam locomotives.

SKF bearings on inside journals pressed on to axle.

SKF bearings on outside journals secured with tapered sleeve nut and lock washer.

Timken bearings pressed on to axle.

(See below for advantage and disadvantage.)

Rail cars.

Bearings pressed on to axle.

Carriages.

Bearings pressed on to axle.

Advantage : greater security as compared with tapered sleeve.

Disadvantage : not so readily assembled and dismantled as compared with the latter.

Ceylon Railways.

No replies.

Pennsylvania Railroad Co., U. S. A.

Roller bearings are pressed on the journal with a hydraulic press. The advantage of this method is that no trouble is experienced with inner races turning and scoring the journal. Tapered sleeves, large axle nuts and locking keys are not required to hold bearings in position when press fits are used.

Sudan Railways.

(a) Split taper bushes, and R. B. races held on these split bushes by tightening nut on the outer end of the journal.

(b) The system is satisfactory no disadvantages.

Indian Government Railways.

Both the cylindrical press-fit and the taper sleeve-fit in use. The latter slightly more expensive but allows for easier machining tolerances. Theoretically, the introduction of two additional machined faces on the taper sleeve can increase the ovality errors.

New Zealand Government Railways.

Steam locomotives.

Cannon boxes : the inner race is pressed directly on to the journal.

Steam locomotives, electric locomotives, multiple units, rail cars, passenger and wagon stock.

Bogie boxes : Timken pressed directly on to journal.

S. K. F. inner race fitted on taper sleeve.

Advantage : can strip bearing with ease.

Disadvantage : if bearing is made of poor material, it is possible to put excessive load on it when assembling.

South African Railways and Harbours.

Tapered roller bearings are mounted directly on the journals with an interference fit requiring approximately 30 — 40 tons pressure. Self-aligning barrel roller bearings are mounted by the above method and also in many instances by means of tapered withdrawal sleeves.

The latter method of mounting has many distinct disadvantages in that it has been frequently found that where insufficient pressure has been applied during mounting, the sleeves will rotate on the journals and cause scoring of the journals. In addition, a large number of failures has been caused by excessive pressure being applied during mounting and this has led to cracking of the inner race of the bearing, thus necessitating replacements.

QUESTION 29.

Do you use special arrangements to prevent electric current passing through the roller bearings (current for traction or heating)?

REPLIES.

BRITISH RAILWAYS

London Midland Region.

Steam locomotives.

Instructions are issued that, when any welding is carried out on a locomotive, the earth should be connected to the locomotive frame and not to the rail, so as to prevent current passing through the bearing.

Electric motor coaches.

On 3rd and 4th rail systems — no special precautions. On 3rd rail systems with running rail return, an earthing brush is fitted on each motored axle.

Eastern and North Eastern Regions.

Electric motor coaches.

No.

London Transport Executive.

The traction current system is of the 4th rail insulated return type, so that no special precautions are required to protect the axle bearings.

Victorian Railways, Australia.

No.

Pennsylvania Railroad Co., U. S. A.

Special arrangements for the prevention of electric current through the roller bearings is used on some of our electric multiple unit cars and experimentally on a few electric locomotives. This arrangement employs a carbon brush to contact the axle with ground to prevent current flow through the journal bearings.

Sudan Railways.

No. No track circuiting or electric traction on these railways.

Indian Government Railways.

No problem yet, roller bearings have not yet been applied on axles of electric locomotives or traction coaches.

New Zealand Government Railways.

Electric locomotives and multiple units.

Brushes bearing on axles carry the main current.

South African Railways and Harbours.

On electric locomotives and motor coaches earth brushes are provided, these having contact on the centre portion of the axle.

b) Axleboxes with bearing or brasses other than ordinary axleboxes with oil pads or packing.

QUESTION 30.

Describe what types of axleboxes having bearings or brasses other than ordinary axleboxes do you use?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

No special types except roller bearing.

Coaching stock.

None.

Eastern and North Eastern Regions.

Electric motor coaches.

None.

Western Region.

None.

Southern Region.

Locomotives.

Isothermos axleboxes fitted to one « Schools » class tender, see Fig. 14. Split type coupled axlebox; figure 8 oil grooves see Fig. 15.

Carriages.

Axleboxes differing from the ordinary type used for motor bogies of multiple unit electric stock, see Fig. 16.

London Transport Executive.

None used.

Victorian Railways, Australia.

All axleboxes other than those referred to previously are of the ordinary type.

Ceylon Railways.

Cast steel and cast-iron axleboxes with slide bearings, some with oil pads and others with cotton waste packing.

Pennsylvania Railroad Co., U. S. A.

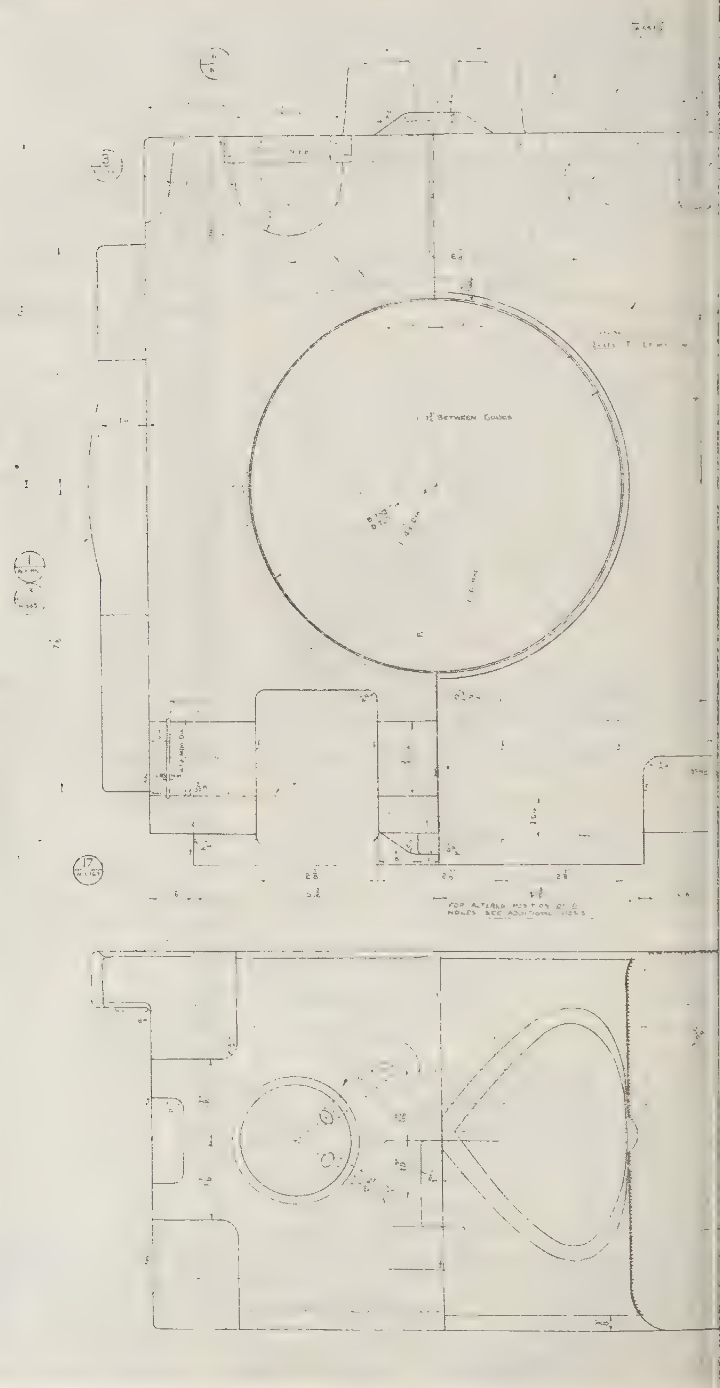
Do not use special boxes for any service. There are three types of bearings in use: roller bearings, bearing metal lined brass bearings and bronze driving box bearings pressed into steel boxes.

Sudan Railways.

Only « Isothermos » boxes (approx. 48 boxes only).

Indian Government Railways.

Nothing to report.



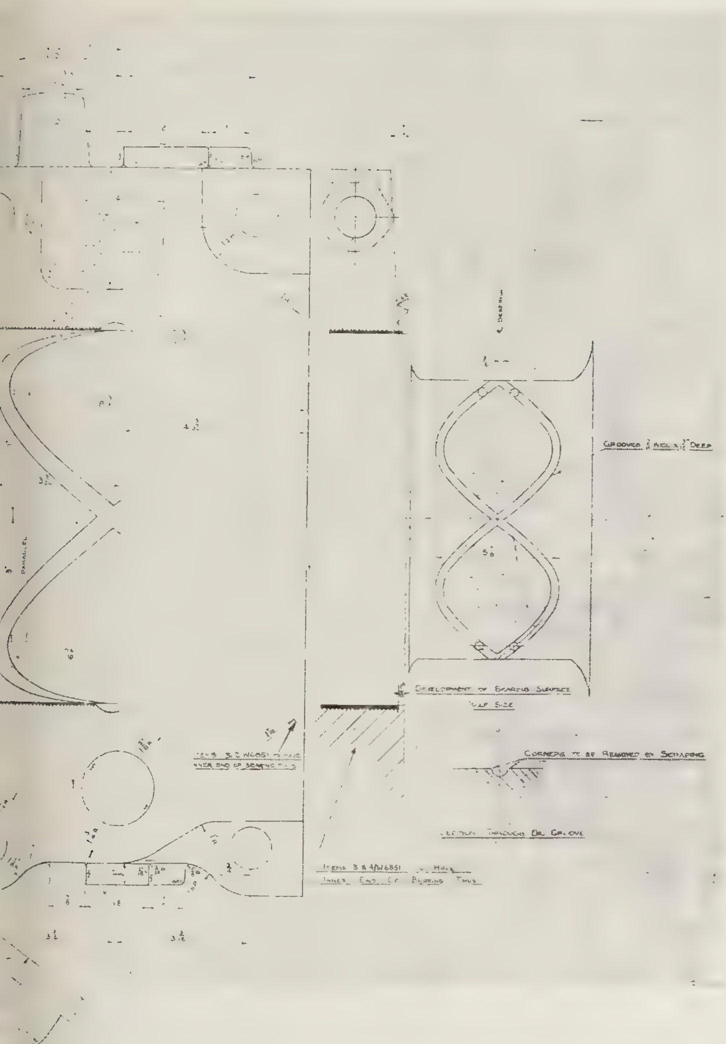


Fig. 15. — Driving axlebox (Divided-type).
British Railways. — Southern Region.

New Zealand Government Railways.

Steam locomotives and other rolling stock. (See below.)

No special axleboxes fitted.

Coaching stock.

Isothermos axleboxes. Satisfactory provided replenishment of oil is not neglected. (See reply to Question 36.)

Wagons.

Have experience difficulty with Isothermos axleboxes due to lack of lubrication, necessary to restrict use to suburban passenger, or similar stock, with limited running for regular attention.

South African Railways and Harbours.

« Isothermos » axleboxes, as manufactured by J. Stonex Co. Ltd. are utilised on the tenders of some steam locomotives.

For main line coaching stock « Isothermos » boxes are now being manufactured by the South African Railways.

QUESTION 31.

What is used for the lubrication of these axleboxes (grease or oil)?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Grease.

Eastern and North Eastern regions.

See reply to Question 30.

Western Region.

See reply to Question 30.

Southern Region.

Oil.

London Transport Executive.

None used.

Victorian Railways, Australia.

All axleboxes other than those referred to previously are of the ordinary type.

Ceylon Railways.

Oil.

Pennsylvania Railroad Co., U. S. A.

Oil lubrication is used for all boxes except the bronze driving box bearing which is lubricated with hard grease.

Sudan Railways.

Oil.

Indian Government Railways.

Nothing to report.

New Zealand Government Railways.

Steam locomotives and other rolling stock.

No special axleboxes other than roller bearings on steam locomotives.

Coaching stock.

Oil. (Isothermos).

South African Railways and Harbours.

Oil.

QUESTION 32.

What type of protection is used against the penetration of dust and water to the interior of these axleboxes?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

No special types on locomotives except roller bearing.

Coaching stock.

We do not use axleboxes other than ordinary types.

Wagons.

See Southern Region.

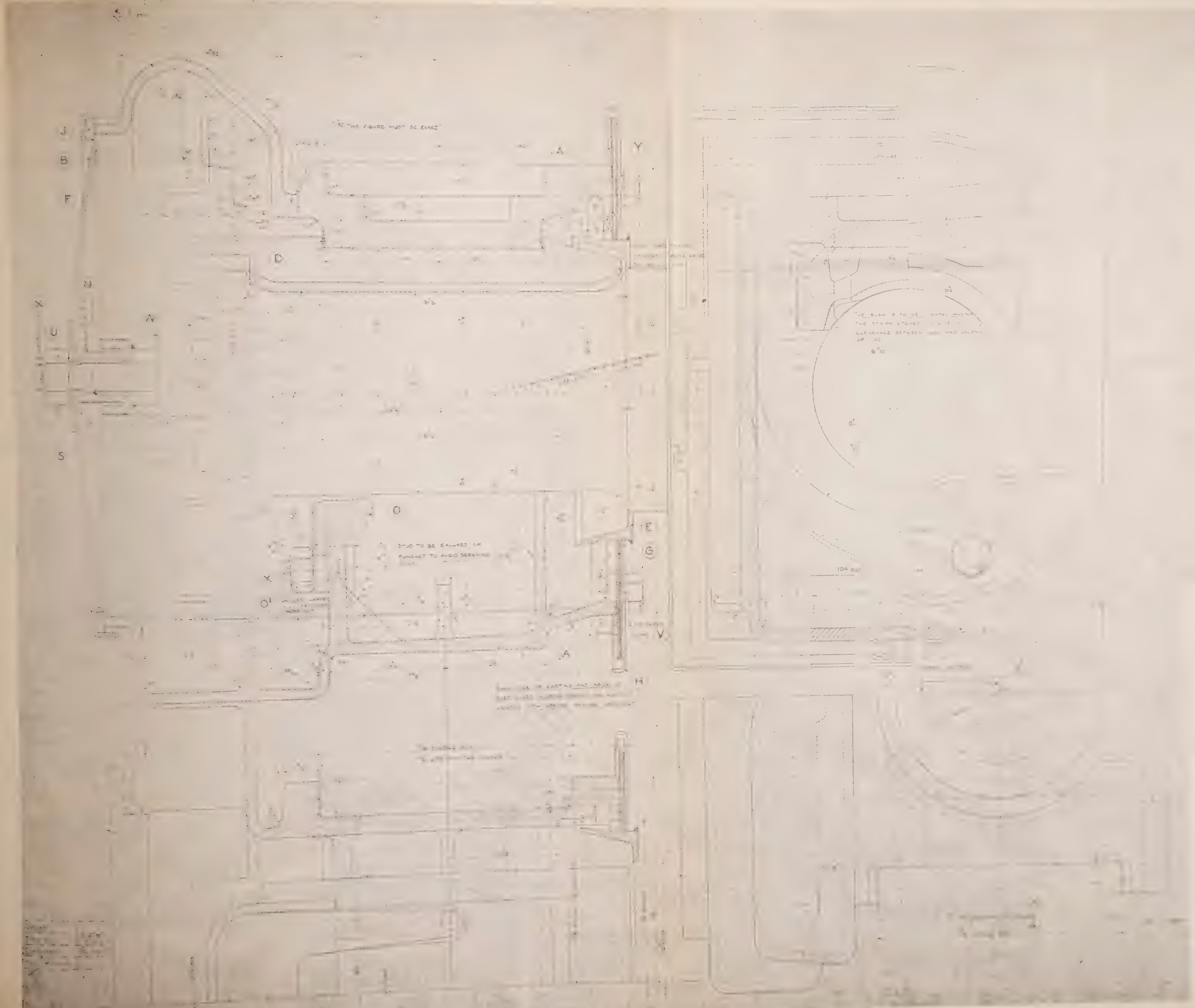


Fig. 14. — Tender axlebox Isothermos (*British Railways, Southern Region.*)

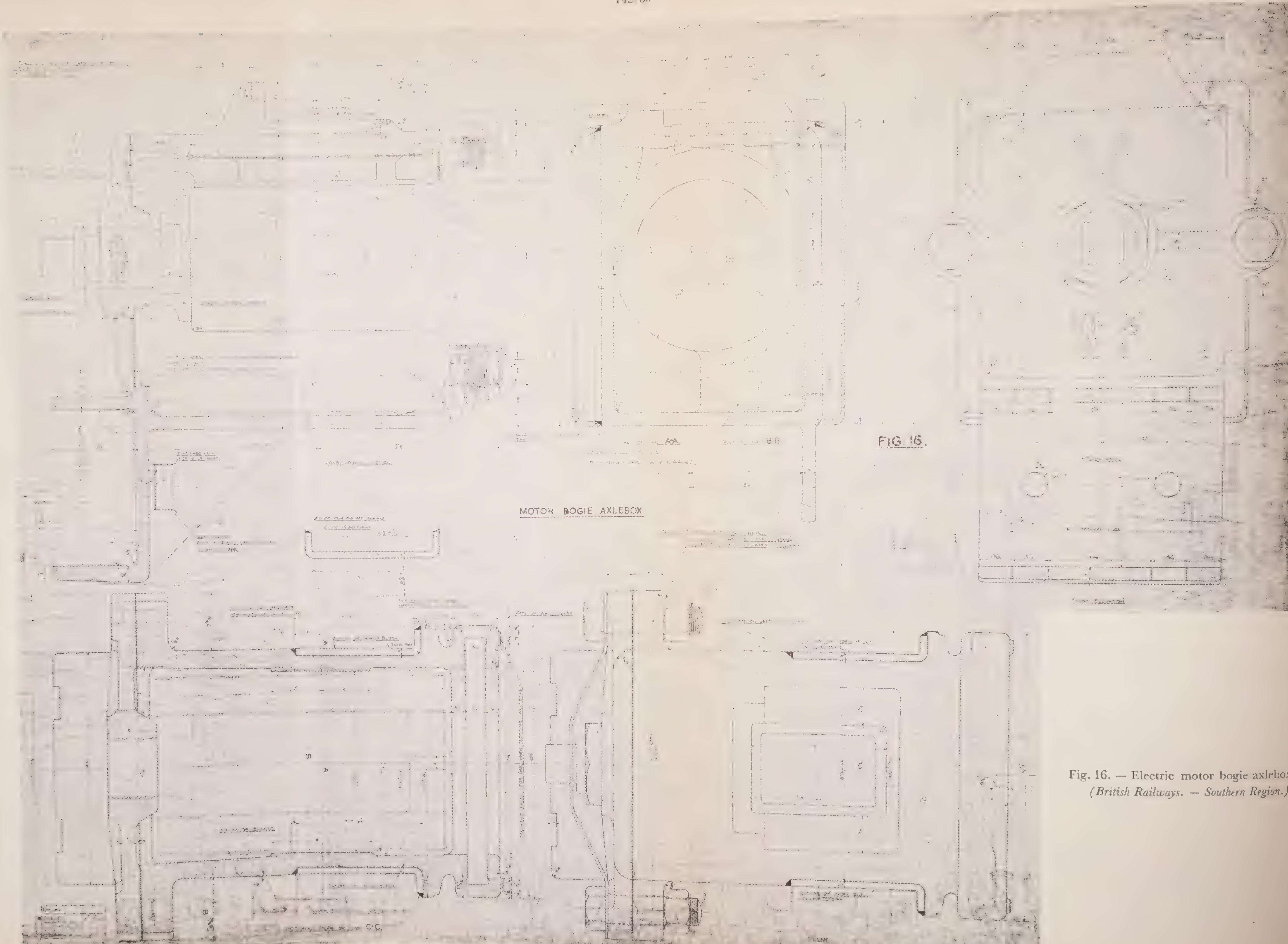


Fig. 16. — Electric motor bogie axlebox
(British Railways. — Southern Region.)

Southern Region.

Locomotives.

Interior protected from dust and water by shields.

In the split type box a screwed cap at the point of entry of the lubricating pipe at the top prevents water or dust entering the axlebox. No provision is made at the sides of the axlebox. Fig. 15.

Multiple unit stock.

Interior protected from dust and water by felt shields.

Wagons.

January 1947 decided to eliminate dust shields from new designs of axleboxes, see Fig. 17.

London Transport Executive.

None used.

Victorian Railways, Australia.

All axleboxes other than those referred to previously are of the ordinary type.

Ceylon Railways.

Double bolted lids and dust shields.

Pennsylvania Railroad Co., U. S. A.

Labyrinthic seals, to retain lubricant and exclude dirt and moisture are used on roller bearing boxes.

Wood dust guards, bored to clossely fit the axle dust guard seat, are used on plain bearing waste packed boxes. We do not use felt rings, etc., for dust seals.

Sudan Railways.

A dust shield in a groove at the inner end of the box. This dust shield is supplied by the makers in a hard pressed fibre material. The two halves are split and half lapped. Surrounding both halves a garter spring is fitted to close up the gap in the hole of the dust shield when created by wear.

Indian Government Railways.

Nothing ro report.

New Zealand Government Railways.

Steam locomotives and other rolling stock, excluding coaching and wagon stock.

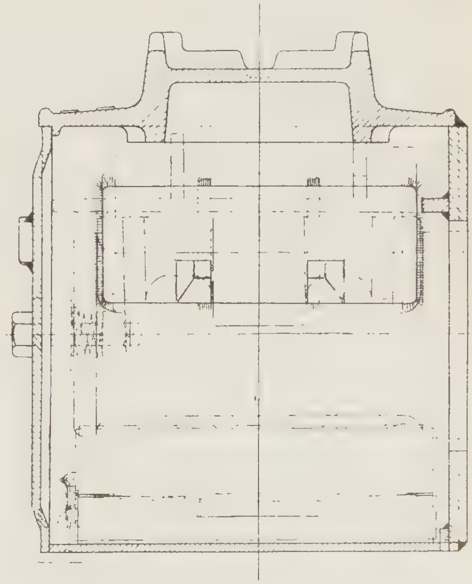
No special axleboxes other than roller bearings on steam locomotives.

Coaching stock.

Leather sealing ring at back of box. (Isothermos.)

South African Railways and Harbours.

Oil slinger rings and leather dust shields are provided.



(Fabricated)

Fig. 17. — *British Railways* (Railway Clearing House pattern.)

c) Improvements to ordinary axleboxes with bearings and brasses.

QUESTION 33.

What improvements have you carried out to brasses and oil pads?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

Improvements to ordinary bearing axleboxes over the last fifteen years include :

Increased bearing surface and reduced pressure per unit of surface. Use of unbroken whitemetal lining, extending over arc of 140° and full length of bearing and keyed to brass or axlebox body by machined serrations in the latter.

Standardisation of pressed-in brasses for coupled axleboxes.

Lubrication by oil pad only, oil being syphoned by pad from keep to which it is fed by mechanical lubricator. Oil pads of strands of worsted woven on a sheet steel frame, shaped to fit journal and with loose ends suspended in oil reservoir. The frame provided with light coil or leaf springs to hold it against the journal. Owing to the extent of yarn used, this pad ensures an adequate oil supply.

Coaching stock.

No radical changes made for 25 years.

Eastern and North Eastern Regions.

Electric motor coaches.

Oil seal lubricators adopted; see Fig. 18 a) and 18 b).

Western Region.

Cast-iron divided type axleboxes are used for carriages and wagons and experience with gunmetal over the whole of the surface in contact with the axle journal, has proved a most satisfactory bearing for carriages and wagons.

Particulars of the whitemetalling process is given in Question 35.

Lubricating pads with packing material of best curled black horse hair and best wool waste and provided with coil springs to maintain even pressure on the journals, have proved the most satisfactory.

Southern Region.

Following established practice.

London Transport Executive.

None of importance.

Victorian Railways, Australia.

Steam locomotives.

Wool waste rolls now used on all locomotive axleboxes. Heavy red bearing oil used in engine axleboxes during the summer season (1st November to 30th April) and light red bearing oil in engine boxes during the winter season (1st March to 30th October) and in the tender boxes through out the year.

Electric motor coaches, cars, wagons.

One piece boxes with hinged lids, spring controlled, have now been adopted as standard practice. Boxes provided with journal bearing wedge and lubrication is by means of wool waste rolls and red oil.

Ceylon Railways.

Oil pads being dispensed with and cotton waste packing introduced.

Pennsylvania Railroad Co., U. S. A.

Improvements to ordinary boxes and bearings have been studied over the years. Various journal box oil pads and mechanical oiling methods have been tried from time to time as they developed but have not shown superiority to present methods.

Sudan Railways.

Nil. (We used wool waste packing — not pads).

Indian Government Railways.

Brasses lined with antifriction metal and waste packing standard for many years.

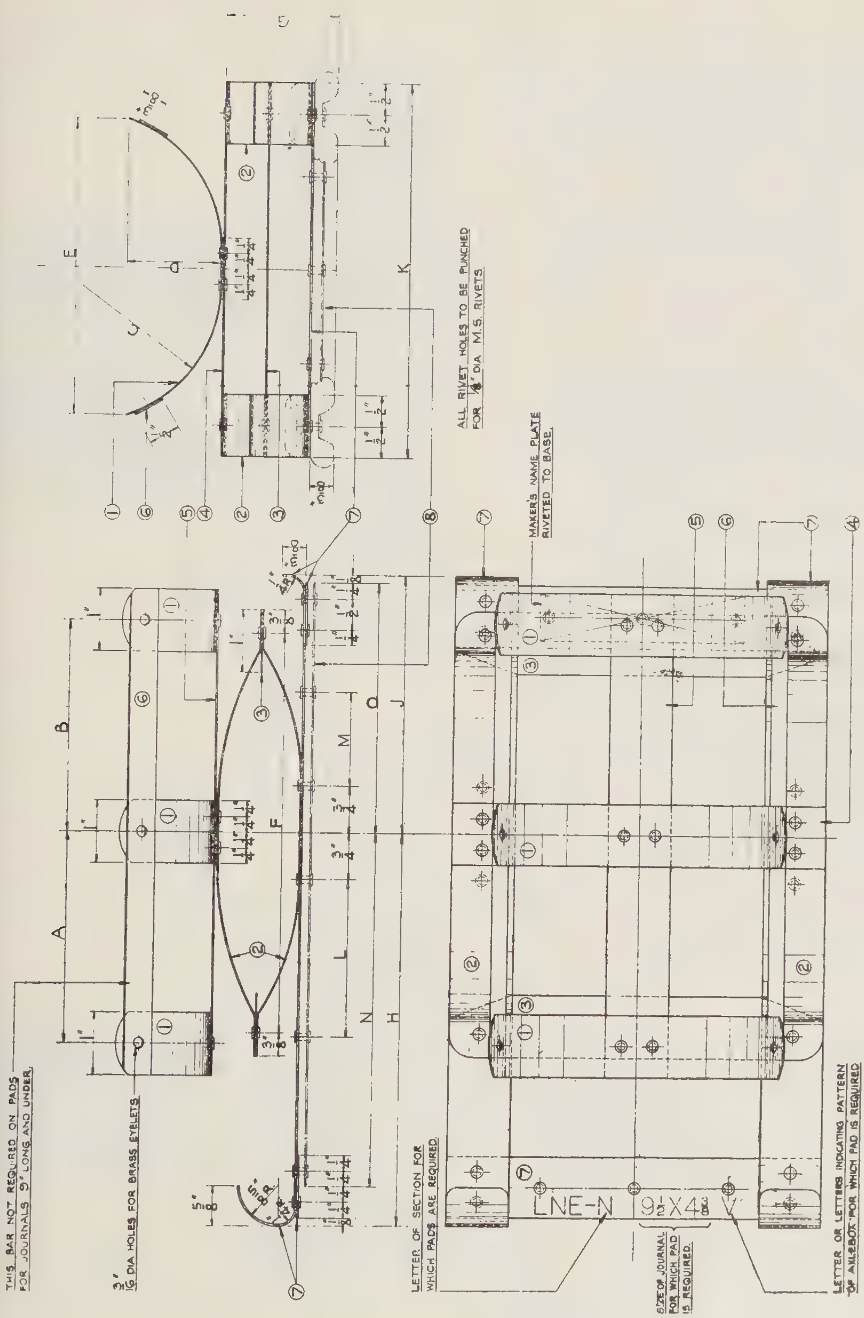
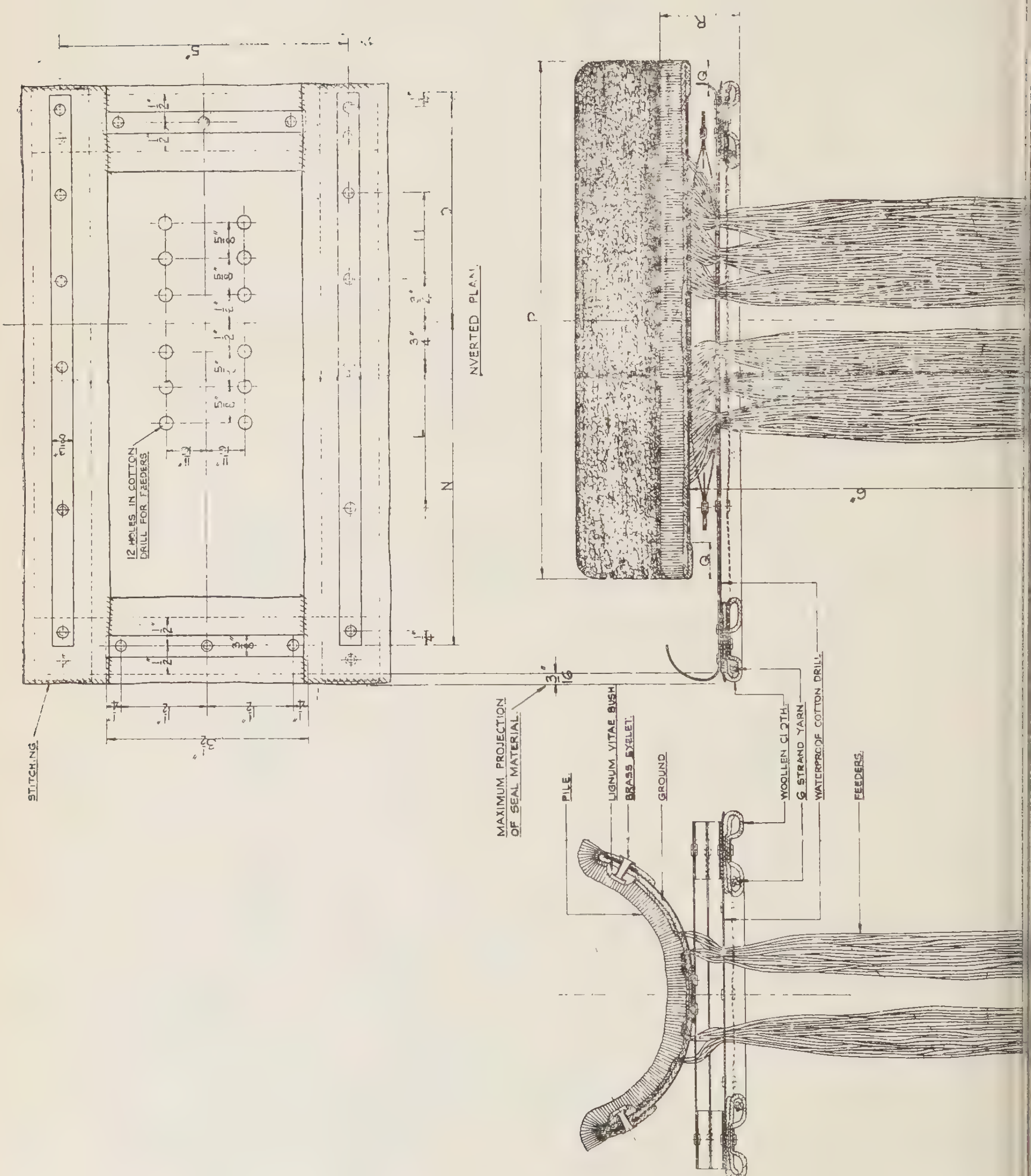


Fig. 18a). — Armstrong Oil Seal Lubrication (*British Railways. — Eastern and North Eastern Regions.*)


12 HOLES IN COTTON DRILL FOR FEEDERS
STITCHING
MAXIMUM PROJECTION OF SEAL MATERIAL
PILE
LIGNUM VITAE BUSH
BRASS EYELET
GROUND
WOOLLEN CLOTH
6 STRAND YARN
WATERPROOF COTTON DRILL
FEEDERS

New Zealand Government Railways.

Steam loocomotives.

Grease pads have been fitted to the coupled axleboxes of « C » and « K » locomotives.

Electric locomotives.

Some have plain bearings. (See also reply to Question 36.)

Coaching stock.

Brasses made deeper to prevent journal from being pushed out during braking, causing waste grabs.

Packing made up from full skeins of wool instead of scrap to improve lubrication.

« Armstrong oilers » (oiling pads with wool wick) have had a limited application and are satisfactory.

Wagons.

Deeper brasses used as for coaching stock. The capacity of the boxes increased to permit storage of a greater quantity of oil and packing. « Armstrong oilers » are in use, but not on wagons that are used on wagon tipplers as oil runs out. Horns have been widened.

South African Railways and Harbours.

No improvements have been made during recent years.

QUESTION 34.

What type of anti-friction alloy is used? Is there a preference for the use of anti-friction metal rich in tin, according to the type of vehicle (load and speed)?

REPLIES.

BRITISH RAILWAYS.

All regions	Alloy number	Chemical Analysis			
		Tin %	Antimony %	Lead %	Copper %
Steam locomotives	W. M. 1	84-86	9-11	0.2 max.	4-6
Recently standardised Whitemetals	W. M. 2	80-85	9-11	0-5	4-6
	W. M. 3	58-60	9-11	27-29	2-4
	W. M. 4	11-13	12-14	73.5 75.5	0-1

Bearings and linings for which used.

Inside big-ends of certain selected main line locomotives.

Inside and outside big-ends generally. Coupling rod bushes. Driving and coupled axleboxes. Trailing truck axleboxes. Slide blocks, crossheads a. eccentric straps.

Locomotive bogie, pony truck, and tender axleboxes.

London Midland Region.

Steam locomotives.

Whitemetal. British Railways' whitemetal Nos. 1, 2, 3 and 4 alloys are used, Whitemetal 3 (60 % tin content) being used for the majority of purposes.

Yes. Alloys of higher tin content viz. whitemetal 1 and 2 (85 %) are used for axleboxes having high unit loading.

Whitemetal 4 alloy (low tin 12 %) is used for bearings of all carrying axles and its use is being extended to other details.

Coaching stock. (See Table p. 748/66.)

Eastern and North Eastern Regions.

Steam locomotives.

Anti-Attrition Metal Company's « C » quality locomotive white bronze or J. Stone and Co's white bronze : 80 % tin content.

Carriages and wagons and electric stock.

Matrix.

Copper	82.00%
Tin	10 25%
Lead	5.25%
Zinc	2.5 %

Class of material	Alloy number	Analysis				Class of vehicle
		Tin	Antimony	Copper	Lead	
Virgin whitemetal	Whitemetal 1	84/86	9/11	4/6	0.20 as impurity	Articulated carriage stock.
Whitemetal	Whitemetal 2	80/85	8/10	4/6	5.0 maximum	Dining cars, sleeping cars, kitchens, postal vans, electric stock and special vehicles.
Whitemetal	Whitemetal 3	58/60	9/10	2/4	Remainder	Other coaching vehicles.
Lead base whitemetal	Whitemetal 4	11/13	12/14	1.0 maximum	Remainder	Large scale experiments are proceeding with type of whitemetal on both carriages and wagons.

Whitemetal.

Ordinary carriages and wagons.

Tin	56%
Antimony	11%
Lead	30%
Copper	3%

Special carriages, i. e., restaurant, sleeping cars, high speed trains and electric stock.

Tin	80%
Antimony	8%
Lead	5%
Copper	7%

Western Region.

Tin base alloy. Tin.............	60%
Lead	28%
Antimony	10%
Copper	2%

for all locomotives, carriages and wagons.

Southern Region.

Whitemetal bearing analysis per cent.

	Locomotives.	*Carriages.*
Copper :	5/6	2/3
Antimony :	10/11	9.5/10.5
Lead :	0/5	27.5/28.5
Tin :	83/85	58.5/60.5

Carriages and wagons over 13 tons.

Copper	2.0/4.0%
Tin	55.0/57.0%
Lead	29.0/31.0%
Antimony	10.0/12.0%
Zinc	.05% maximum
Aluminium........	.05% maximum
Iron..............	.08% maximum

Wagons under 13 tons.

Railway Clearing House.

Whitemetal.

Copper	1.0%
Tin	11.0/13.0%
Lead	74.0/76.0%
Antimony	12.0/14.0%

London Transport Executive.

The anti-friction metal used for axle bearings has the following composition :

Tin : 36 %. — Antimony : 10 %. — Copper : 2 %. — Lead : 52 %.

This has proved satisfactory in service and is more economical than an alloy with a higher tin content.

Victorian Railways, Australia.

The lining for journal bearings for locomotive tender car and wagon bearings is known as B. 17—JBL (journal bearing lining) the composition per cent :

Tin	3 — 5
Antimony	8 — 9
Arsenic (maximum)	0.2
Copper (maximum)	0.5
Tin, antimony, lead and arsenic	99.25
Iron (maximum)	0.05
Zinc	0.25
Aluminium (maximum)	0.10

On all bearings on engines, armature bearings and journal bearings of electric motor and trailer coaches of suburban rolling stock lining is known as B. 19—C. A. T. metal, the composition per cent :

Antimony	12 — 13
Copper	3 — 4
Tin (balance)	83 — 85

Ceylon Railways.

Whitemetal (tin base) on locomotive bearings. Whitemetal (lead base) on carriage and wagon bearings.

Pennsylvania Railroad Co., U. S. A.

Composition of journal bearing lining is :

Copper (maximum)	0.5%
Lead (minimum)	85.25%
Tin (maximum)	6.0%
Antimony (minimum)	8.0%

The above composition is used for lining journal bearings regardless of the weight or speed of the equipment. All bearings have the same lining metal regardless of speed or service.

Sudan Railways.

Locomotive specification.

J. Stone and Co. Ltd's Class « C » (Analysis not known).

Carriage and wagon specification.

Lead	75%
Tin	12%
Antimony	13%

As mentioned above our conditions are quite exceptional and for carriage and wagon work an anti-friction metal rich in tin does not wear much better than any other. Under desert conditions it is possible to wear through 1/4″ of good whitemetal in some 10 000 miles running.

For locomotives an anti-friction metal rich in tin is the most successful in practice.

Indian Government Railways.

Classification of anti-friction metal.

Indian Railway standard specification.

Class 1. Locomotives bearings.
Class 2. Metallic packing for piston and valve rods.
Class 3. Carriage and wagon bearings.
Class 4. Motor and high speed engine bearings.
Class 5. Locomotive axlebox and connecting rod big end bearings.

Class.

Chemical composition	1	2	3	4	5
Tin	19/21 %	13/15 %	4.5/5.5 %	Remainder	29/31 %
Antimony	14/16 %	10/12 %	14/16 %	9/11 %	14/16 %
Copper	1.25/1.75 %	—	0.75/1.25 %	5/6 %	1.5/2 %
Total impurities	Not more than 0.5 %	Not more than 1.0 %	Not more than 1.0 %	Not more than 0.5 %	Not more than 0.5 %
Lead	Remainder	Remainder	Remainder	2/3 %	Remainder

New Zealand Government Railways.

Steam and electric locomotives, coaching and wagon stock.

Standard white metal 86 % lead, 14 % antimony. No differentiation for loads and speeds.

South African Railways and Harbours.

The following alloys are used for oil lubricated boxes :

Electric locomotives and motor coaches.

Tin	83 %
Antimony	11 %
Copper	6 %

Steam locomotives.

Tin	76 %
Antimony	11 %
Lead	7 %
Copper	6 %

This high tin alloy is used as bearing metal for all points on steam locomotives.

Carriage and wagon stock.

Antimony	15 %
Lead	80 %
Tin	5 %

QUESTION 35.

Describe the method of applying the anti-friction metal (grinding, centrifugal, sintering, fritting, etc.) and the minimum thickness of the layer.

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

The whitemetal is applied in a molten state after firstly tinning the brass to ensure a good bond. The minimum thickness of the whitemetal layer, after machining, is 1/8″ over the tops of the serrations in the brass.

Coaching stock.

The anti-friction metal is chill cast to bearing.

Minimum thickness of anti-friction metal :
Carriage stock : 1/8″.
Wagon stock : 3/32″.

Eastern and North Eastern Regions.

Locomotives, carriages, and wagons.

Tinning mixture.

Tin : 49/51 %.
Antimony : not more than 0.5 %.
Lead : difference.

Bearing machined, and after machining the surfaces are wire brushed for whitemetal in a chill. White-wash is applied to surfaces which are not whitemetal. The remaining surfaces are brushed with killed spirits of salts or an approved soldering liquid, and are then tinned to the tinning mixture stated above. Temperature of tinning bath is about 320° C. Bearing after it has been allowed to stand is then dipped into the bath a second time to raise its temperature and wire brushed before being placed in the chill, which has a temperature of about 650° C. Chill is inclined to an angle of 30° C; the back of bearing being uppermost. Whitemetal is then poured into chill and stirred in risers to ensure homogeneous casting.

Pouring temperature of 56 % tin content white metal to be 440° C/ 450° C.

Pouring temperature of 80 % tin content whitemetal to be 450° C/ 475° C.

Western Region.

Bearings are rough bored to give serrations of nine per inch. The metalling process consists of five operations, and it is of the utmost importance that a minimum of time elapses between each :

(1) Limewashed on sides and back.
(2) Preheated until stick of solder rubbed on brass shows sign of running.
(3) Brushed with killed spirits.

(4) Immersed in bath of molten solder.
Temperature of brass before entering bath 180° C.
Temperature of brass on leaving bath 270° C.

(5) Brass placed on chills and metal poured in. Pouring temperature 350° C to 380° C.

Southern Region.

Locomotives.

Bearings are either ground or shot-blasted, turned and metalled in a chill.

Minimum thickness of whitemetal on latest express engine coupled axleboxes is 1/16″.

Carriages and wagons.

(*a*) The brass is coated with white-wash on all parts except where tinning is required.

(*b*) Pre-heat being to a temperature 180° C.

(*c*) The brass is coated with soldering fluid (zinc chloride and salammonia) where tinning is required. Fluid applied with brush.

(*d*) Immerse brass in tinning bath (composition tin 2, lead 1) temperature entering bath 180° C. Temperature leaving bath with 3/16″. thickness of whitemetal 302° C. with 3/32″ thickness of whitemetal 320° C.

(*e*) Brass placed on chill and metal poured at 3/16″ thick 370° C. 3/32″ thick 420° C. Temperature of chill 50° C to 100° C when pouring.

London Transport Executive.

After machining, the unmetalled bearing is sand blasted and the surface tinned. The whitemetal is applied by pouring into the bearing while it is placed on a mandrel occupying the same relative position as the axle. Before fitting to the axle, the bearing is machined on a reamering machine. The minimum thickness of the layer for a 9″ × 5 1/2″ journal is 1/4″.

Victorian Railways, Australia.

New bearings are thoroughly cleaned by sand blasting. Used bearings are cleaned by boiling down and de-metalled by open fire, gas oven, or pot method, and if in good order are re-metalled. Care is taken to clean all dirty patches by wiping with cotton cloth (not cotton waste) scraped to clean the gunmetal surface and again wiped with cotton cloth or blown with compressed air. Importance of perfect tinning is stressed; overheating indicated by discoloration must be avoided. The flux used is killed spirits or stick sal. ammoniac.

When tinning is completed the brass is allowed to cool to 150-180° C. Mandrel used should be at approx. the same temperature. The melted C. A. T. metal is raised to a temperature not lower than 375°C nor higher than 400°C and thoroughly stirred. Dross is removed, and bearing is poured so that all gas is forced out of the mould and the metal solidifies from the bottom upwards. The minimum thickness of lining applied is 5/16″.

Ceylon Railways.

Cleaned and tinned bearings are metalled in special moulds.

Pennsylvania Railroad Co., U. S. A.

Journal bearing is prepared for lining by boring and tinning the surface to be lined. Molten lining metal is poured into an opening between bearing and a mandrel at a spacing required to give the proper lining thickness. The thickness of lining metal is 1/4″ when new.

Sudan Railways.

(*a*) Cleaning by acid.

(*b*) Tinning.

(*c*) Filling under gravity in chills. Metal thickness 1/4″.

Indian Government Railways.

The thickness of the lining about 3/8″ minimum. Anti-friction metal cast into the bearing.

New Zealand Government Railways.

Steam and electric locomotives.

White metal is cast in.

Coaching and wagon stock.

White metal is cast in, the brass shell being first tinned, and the molten metal is poured into the heated shell.

Thickness 1/4″ at crown.

South African Railways and Harbours.

Cast on to a cleaned gunmetal bearing surface in a suitably designed cast iron chill holding the bearing in position. The minimum thickness of the layer is 1/8″.

d) Present practice in the choice of the type of box.

QUESTION 36.

Set out the different categories of locomotives and rolling stock, and the various type of service which govern the choice of the type of boxes to be adopted, showing the reasons.

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

Locomotives are divided into the following categories :

Passenger : tender and tank.
Mixed traffic : tender and tank.
Freight : tender and tank.

The type of axlebox is not generally influenced by the class of locomotive service.

Roller bearing boxes are used on a few passenger and mixed traffic locomotives with the object of eliminating hot boxes and increasing mileage between shoppings. Locomotives of new design in any of these categories are provided with axleboxes embodying the latest features of design referred to in answer to Question No. 33.

Coaching stock and wagons.

Two types, the open fronted and the divided. The former is used on carriage stock giving easy access to bearing and lubricating pad. The divided type is of the inkwell tipping pattern and its use is confined mainly to wagon stock. Steel fabricated axleboxes of the open fronted type are also used on wagons.

Eastern and North Eastern Regions.

Oil boxes with pad lubrication generally used.

Western Region.

Locomotives.

Cast steel boxes with bronze crown brasses, these brasses being lined with whitemetal. Hornways fitted with bronze liners.

Carriages and wagons.

Cast-iron boxes in two halves. Loose brasses lined with whitemetal.

Above designs chosen because of long life, low first cost and low maintenance costs.

Southern Region.

Locomotives.

Do not select type of axlebox to suit duty, improvements are embodied as opportunity occurs.

Carriages.

Open fronted type axleboxes of cast iron, cast steel used for steam and electric stock. Cast steel used for motor bogies and used fabricated axleboxes for double-deck trailer bogies to reduce weight.

Open fronted axleboxes make for easy inspection and attention of bearing details. Normally axleboxes of cast-iron are cheapest and meet service conditions.

Wagons.

Divided and open fronted types made from cast-iron are in use and prone to failure. Recently a number of cast steel and fabricated mild steel axleboxes have been put into services : both types dearer than cast-iron, but longer life expected, thereby justifying cost.

London Transport Executive.

Roller bearing axleboxes are being adopted for all future passenger stock on account of their freedom from trouble and reduced maintenance costs.

Victorian Railways, Australia.

Steam locomotives.

High speed passenger and general service : Preference : roller bearings.

Reason : reduction of maintenance, reduced starting friction.

Goods service : present practice : gun-metal, brasses with C. A. T.—B. 19 metal lining in two piece boxes or one piece boxes without slipper.

Reason : minimising end wear on journal.

Electric locomotives.

High speed passenger and general service : Preference : roller bearings.

Reason : reduction of maintenance, reduced starting friction.

Goods service :

Preference : GM brasses with C. A. T.—B. 19 metal lining.

Reason : reduction of first cost.

Rail cars.

General service :

Preference : roller bearings.

Reason : reduction of maintenance, reduced starting friction.

Electric motor coaches.

General service :

Preference : roller bearings, but first cost is a limiting consideration.

Cars.

High speed passenger and general service :

Preference : roller bearings.

Reason : roller bearings.

Less important stock.

Present practice : journal bearing metal M. J. B. — B. 26 lined with journal bearing lining.

Wagons.

Journal bearing metal M. J. B. — B. 26 lined with journal bearing lining J. B. L. B. 17.

Reason : idem.

The type of axlebox preferred for plain bearings is the hinged lid one piece box having journal bearing wedge, the removal of which permits the withdrawal of the journal bearing without lifting the vehicle.

Ceylon Railways.

No reply.

Pennsylvania Railroad Co., U. S. A.

Locomotives driving boxes are of heavy steel construction to withstand the stress of service. Car boxes are designed to suit the spring application and are cast-iron or steel.

Sudan Railways.

(a) *Locomotives.*

Brass crown and side horse shoe liners, on a steel box, wool waste packing. White metalled pockets in crown brass.

(b) *Carriage and wagon.*

(All except the 120 roller bearing boxes, and the 48 Isothermic boxes referred in replies to previous questions.)

Cast-iron boxes with loose cast-iron slippers and white metalled brasses, wool waste packing.

In this category Isothermos boxes are preferred to all other types (see answer to Question 30) on account of their freedom from hot boxes and less attention being necessary between shopping. First cost is much greater than for equivalent normal carriage and wagon oil lubricated axleboxes.

Indian Government Railways.

Cast steel and bronze composite axleboxes standard for oil lubrication. Cast steel boxes with slip in bronze or solid bronze boxes standard for grease lubrication. Cast steel axleboxes standard for carriage and wagon stock. Such boxes permitted for all services.

New Zealand Government Railways.

Steam locomotives.

Roller bearing driving and bogie boxes have been fitted on the more recently designed locomotives used for high speed work. On earlier high speed locomotives, roller bearing bogie boxes were adopted where these seemed desirable.

Electric locomotives.

Of the four types of electric locomotives two have plain bearing axleboxes, the other two roller bearings : reason, application of roller bearings is a later development, the type of service has had no bearing on the matter. (See also reply to Question 33.)

Multiple units and rail cars.

Have roller bearing axleboxes.

Passenger stock.

Passenger cars and vans more recently built and running on express services have roller bearings. (See also reply to Question 30 re. Isothermos axle boxes.)

South African Railways and Harbours.

Selection of type of axlebox is made from the load speed factors and the desirability of freedom from hot boxes.

E. WEARING AND FRICTION METALS

QUESTION 37.

What are the details, in your opinion, the wear of which limits the mileage between repairs?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

Principally tyres; axlebox guide and wheel faces and, to a lesser extent, journals; piston valve liners.

Coaching stock.

Tyre wear limits the mileage between repairs on both carriages and wagons.

Eastern and North Eastern Regions.

Steam locomotives.

Tyres, motion, valves and piston, brake rigging.

Electric motor coaches.

Tyres, bolster clearances, side bearer pads, brake rigging.

Carriages.

Tyres, bolster clearances, side bearer pads, brake rigging.

Wagons.

Principally tyres.

Western Region.

Locomotives.

Wear of crossheads, coupling and connecting rod bushes and cylinder and piston valve liners, also tyres and axleboxes.

Carriages and wagons. — hollowness of tyres.

Southern Region.

Locomotives.

Motion details, pistons, tyres, and axleboxes.

Carriages.

Tyres, axleguards, bogie suspension gear.

Wagons.

Tyres, axleguards, axleboxes, draw and buffing gear.

London Transport Executive.

If « repairs » is interpreted as work carried out at running depots, then tyre wear (i. e. sharp and deep flanges) is the limiting factor.

Victorian Railways, Australia.

Steam locomotives.

Wear of boxes on hub faces.

Electric locomotives.

Thickness of journal bearing lining.

Electric motor coaches, cars, wagons.

Thickness of journal bearing lining.

Ceylon Railways.

No reply.

Pennsylvania Railroad Co., U. S. A.

Worn wheel treads require more frequent hopping of cars than any other single tem, but the car is not placed in shop or this attention. Wheels are removed at a « drop pit » and reapplied after re-onditioning. There are no details on ur equipment on which the wear esta-lishes the period between shoppings; but, when running repairs of equipment become so frequent, it is shopped for classified general) repairs. The periods between lassified repairs are listed under answer -- 1.

Sudan Railways.

Chief cause of trouble is the wear created y the ingress of dust, causing an abrassive ction on the bearing.

Indian Government Railways.

Nothing to report.

ew Zealand Government Railways.

eam locomotives.

Tyre wear, axlebox wear, crank pin ear, piston rod wear in spring gear.

lectric locomotives and multiple units.

Tyre wear. Wear in spring gear and ake rigging. Wear in motor bearings. he application of roller bearings to motors s improved the mileage figure between erhauls.

il cars.

Fabricated material and manganese steel, axlebox guides, bogie bolster guides, le control piston bearing plates, and at plates.

Coaching and wagon stock.

Tyres, axleboxes, axlebox guides, brake rigging and condition of bodywork.

South African Railways and Harbours.

Steam locomotives.

Crown knock, condition of tyres and front end, and position of horn wedges are usually deciding factors apart from the boiler and general condition of the locomotive. The service, nature of track and attention at last intermediate repair determines whether boxes, tyres or wedges are mostly in need of repair.

QUESTION 38.

What materials are used to reduce the wear of details subjected to friction (axlebox guides, various joints, etc.)?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

Manganese steel for axleboxes and guides; special wearing materials not used in general for any other details. Nitrided surfaces tried for piston valve liners, but no appreciable improvement over ordinary cast-iron. Nickel cast-iron for piston rings was also unsuccessful.

The use of case-hardening steel for certain details, including some pin joints, has been superseded by that of 32 — 38 ton steel not case-hardened, but case-hardened bushes have been used extensively as an alternative to bronze for motion bushes.

Coaching stock.

Manganese steel liners are used on the axleguards and axleboxes of the motor bogies on electric stock and steam stock to a limited extent.

Eastern and North Eastern Regions.

Locomotives.

Manganese steel liners have been fitted to axleboxes and horn faces in conjunction with both plain and roller bearings coupled and carrying axleboxes.

Chrome hardened piston valve liners have been tried but no appreciable improvement could be determined over standard sand cast liners.

Extensive use of high carbon steel bushes in brake gear.

Carriages and wagons.

Manganese steel liners have been fitted to axleboxes and horn rubbing faces and to bolster rubbing blocks and faces.

Extensive use of high carbon steel bushes in brake gear.

Western Region.

Locomotives.

Cast steel boxes with bronze crown brasses, these brasses being lined with whitemetal. Hornways fitted with bronze liners.

Carriages and wagons.

Cast iron boxes in two halves. Loose brasses lined with whitemetal.

Above designs chosen because of long life, low first cost and low maintenance costs.

Southern Region.

Locomotives.

Manganese steel, bronze and whitemetal.

Carriages.

Axlebox guides fitted with manganese liners.

Bolster rubbing plates.

Use fabricated materials in conjunction with cast iron wearing plates, average life 4 1/2 years. Wearing plates are refaced and used again.

Fabricated material when worn can be utilised for other purposes.

Bogie bolster suspension Fig. 19.

Since 1934 have used non-adjustable knife-edge bolster swing links.

Vehicles adjusted by shims under the bolster springs: no links yet replaced due to wear.

London Transport Executive.

Manganese steel is used for many parts liable to wear, such as axlebox guides and buffing gear wearing surfaces.

Victorian Railways, Australia.

Steam locomotives.

Hubliners of C. A. T. — B. 19 metal.

Composite liners of « Mintex » ZSL and « Railko » are being submitted to test.

13 to 14 % manganese steel for horn cheek liners. Phosphor bronze PB. B 3 for horn shoes and wedges.

Electric locomotives.

Wearing plates of ingot iron or mild steel. Plates case-hardened for axlebox and horn cheek liners.

Rail cars.

« Mintex » used for wearing surfaces of axelbox of Walker Diesel rail cars.

Electric motor coaches.

As for electric locomotives.

Cars.

Timken roller bearing axleboxes have liners of 13 to 14 % manganese steel welded on.

Wagons.

Wearing plates of spring steel hardened or mild steel case-hardened are welded or riveted on wearing surfaces.

Ceylon Railways.

Manganese steel, « Mintex », « Ferobestos » anti-friction materials tried and given up due to difficulty in obtaining these locally for replacements. Non-ferrous liners

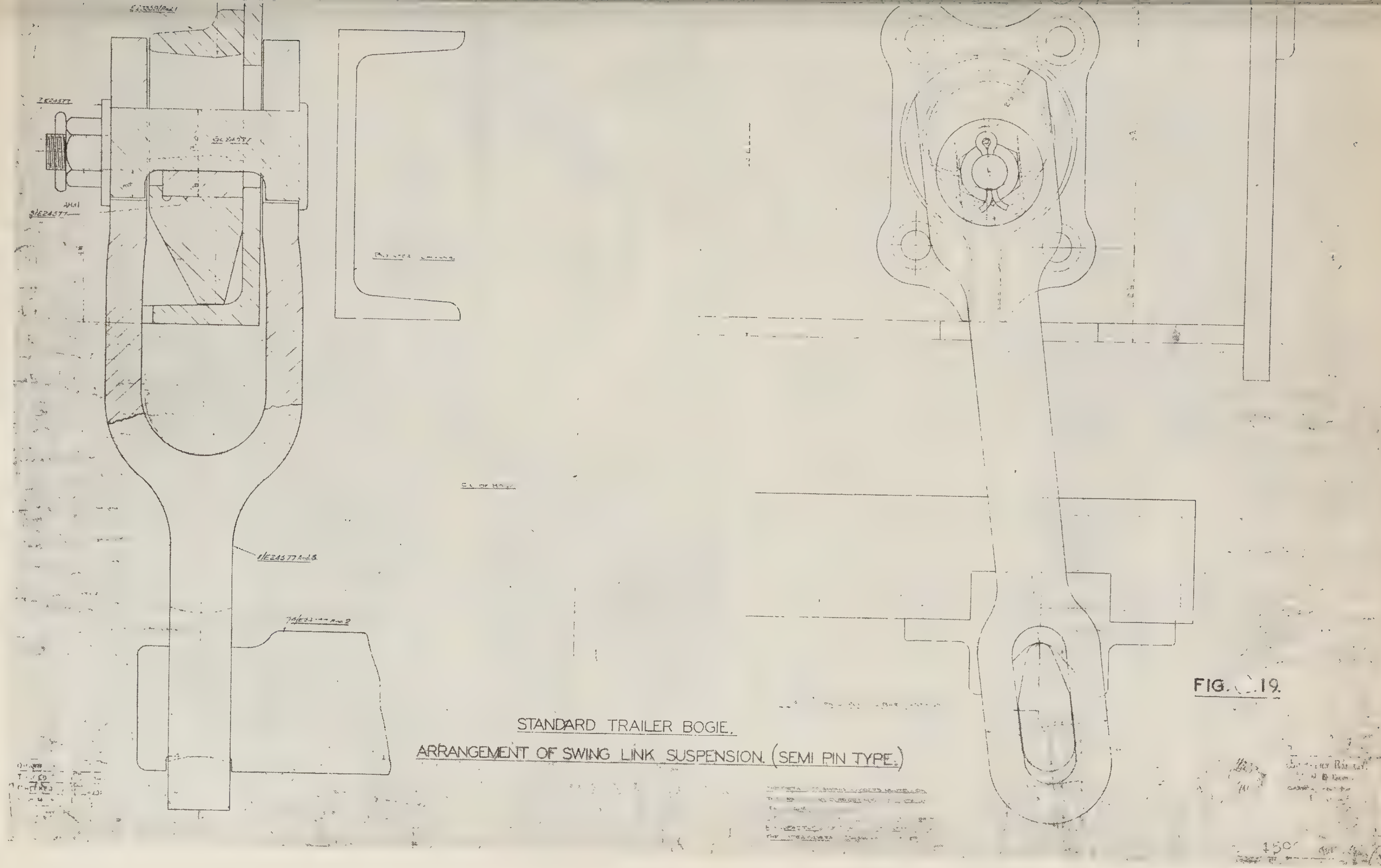


Fig. 19. — Swing link suspension. (Semi-pin type) for carriage bogie. *(British Railways. — Southern Regions).*

anti-friction whitemetal etc., are used instead.

Pennsylvania Railroad Co., U. S. A.

Journal (axle) box guides and truck frames have hardened steel liners to reduce wear. Brake levers, generator hangers, swing (bolster support) hangers and other points of wear are equipped with hardened steel bushings to reduce wear to the minimum.

Sudan Railways.

Nil. Found cheapest to build up worn parts.

Indian Government Railways.

Nothing to report.

New Zealand Government Railways.

Steam locomotives, electric locomotives, multiple units and coaching stock.

Fabricated material and manganese steel liners (axleboxes, horn guides, bogie centres).

Rail cars.

Fabricated material and manganese steel liners (axleboxes, horn guides, bogie centres). See 37. Lay-rub joints in all transmission shafts, Timken rollers for bogie centres.

Wagon stock.

Axlebox guides manganese steel liners fitted by welding, and axleboxes are also made in cast steel instead of cast iron. The guides have been made wider.

South African Railways and Harbours.

Coupled wheel axlebox guide shoes and wedges are forged from steel 45 tons tensile. Locomotive and tender bogie axlebox guide shoes are cast iron.

Coupling rod knuckle joint pins are of steel, case-hardened, working in bronze bushes.

Coupling and connecting rods are fitted with steel fixed bushes (45 tons tensile unhardened) pressed into the rod and bronze floating bush between steel bush and crank pin. Lubrication is by hard grease.

All valve motion parts are fitted with bronze bushes working on case hardened pins. Holes for pin in brake and spring gear on locomotives are fitted with bushes of steel, case-hardened, and pins are also case-hardened.

On carriage and wagon stock, the pins and bushes in the brake gear are not case hardened.

The use of 11 % — 14 % manganese steel wearing plates, either castings or rolled plate liners, has been found advantageous mainly on roller-bearing axleboxes and guides and the practice is being gradually extended.

QUESTION 39.

What methods have you adopted to make good worn details (e. g. fitting washers or bushes at joints, using easily replaceable wearing portions, etc.).?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

The following are examples of the application of the principle of renewable wearing portions :

Piston head rubbing pieces.
Axlebox flanges.
Axlebox guides.
Delivery cone of exhaust injector.
Boiler expansion angle liners.
Intermediate buffer heads.

Making good worn details by re-bushing, building up by welding and re-whitemetalling is normal practice.

Coaching stock.

The liners and fork ends of all pin joints on carriage brakework are bushed with case-hardened or heat treated steel bushes.

Eastern and North Eastern Regions.

Worn piston heads where integral with rods are built up on periphery and re-turned.

Axlebox steel boss faces renewed by fitting bronze liners.

General practice on locomotives, carriages and wagons to build up worn details by welding and bushing or re-bushing.

Western Region.

By fitting of washers and bushes where practicable and economical.

Southern Region.

Locomotives.

Worn details repaired by nickel-plating, welding and bushing. In new designs details subject to wear are bushed.

Carriages.

Case-hardened bushes in details subject to wear at pin holes. Pins are also case-hardened.

Worn parts are also built up by welding where worthwhile.

Wagons.

Worn parts built up by welding where worthwhile.

London Transport Executive.

Extensive use is made of bushes for wearing joints, etc. Manganese steel wearing pads are fitted on the bogie frame.

Victorian Railways, Australia.

Most holes for pins for brake gear, spring gear, etc., are provided with bushes of ingot iron or steel class J, bright drawn steel or solid drawn steel tubing all of case hardening quality.

They are carburised after machining for stock then hardened after cutting or drilling for oil holes and grooves.

Mild steel replaceable wear parts are used for spring seats on axleboxes.

Ceylon Railways.

Yes.

Pennsylvania Railroad Co., U. S. A.

All major wear points are fitted with bushes or removable wearing plates that can be renewed when excessively worn.

Sudan Railways.

All brake gear bushed in machine shop.

Indian Government Railways.

Use replaceable wearing portions or bushes.

New Zealand Government Railways.

Steam and electric locomotives, and multiple units.

Liners, renewable bushes, repair sizes of packing (for springs) and welding.

Rail cars, coaching and wagon stock.

Bushes and pins in brake gear, spring gear, bogie bolster control gear, exhaust mountings, as applicable.

South African Railways and Harbours.

Easily replaceable wearing portions, in the form of renewable liners or bushes, are provided wherever practicable.

QUESTION 40.

Have you adopted any special arrangements to avoid reciprocal friction between the different details (e. g. guiding by articulated links on silent bloc, etc.)?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

No.

Eastern and North Eastern Regions.

No.

Western Region.

No.

Southern Region.

No.

London Transport Executive.

Experiments with a new type of rubber bolster suspension are in progress.

Victorian Railways, Autralia.

No, except that rotation of pin in a fork and eye joint is prevented in one of the articulated members.

Ceylon Railways.

No.

Pennsylvania Railroad Co., U. S. A.

Use anchor rods to position passenger car truck bolsters where the movement is compensated for by the deflection or rubber washers.

Sudan Railways.

No.

Indian Government Railways.

Nothing to report.

New Zealand Government Railways.

Steam locomotives.

The Baker-Pilliod. Valve gear used on « J » and « Ja » locomotives replaces the sliding die block and expansion link of the standard Walschaert motion by a system of levers with needle roller bearings.

South African Railways and Harbours.

No.

QUESTION 41.

Do you use with spring suspension details any protection devices on the parts subjected to friction (supports for the adjusting spring links, buckles, etc.)?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

No.

Eastern and North Eastern Regions.

Steam locomotives.

No.

Electric motor coaches, carriages and wagons.

Bogies have knife edge suspension.

Western Region.

No.

Southern Region.

No.

London Transport Executive.

No.

Victorian Railways, Australia.

No, except for some passenger bogies, where safety straps are provided under the spring borne bolsters.

Ceylon Railways.

No.

Pennsylvania Railroad Co., U. S. A.

Adjustable spring links are no longer used on this railroad and all adjustment necessary is made with steel shims.

Wear points are usually hardened steel surfaces.

Sudan Railways.

No.

Indian Government Railways.

Nothing to report.

New Zealand Government Railways.

All rolling stock, other than electric locomotives.

No.

Electric locomotives.

Safety brackets incorporated with the spring gear.

South African Railways and Harbours.

No.

F. SPRINGS.

QUESTION 42.

What methods have you adopted to lessen the number of spring failures (weakening, fractures, etc.)?

a) for laminated springs;
b) for spiral springs;
c) for volute springs;
d) for other types of springs (torsion bar, etc.).

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

(*a*) Rigid inspection of material. Careful examination of plates at repair.

Reduction in deflection at scrag test.

$$\text{Deflection} = \frac{(\text{Length of top plate in inches})^2}{1200 \times \text{thickness of plates in inches.}}$$

Adoption, where practicable, of wedge fixing for buckle obviating drilling or slotting of plates in centre.

(*b*) Rigid inspection of material. Careful examination at repair.

Coaching stock.

We do not suffer from spring failures to any extent other than wagon buffing and drawgear springs which have been strengthened or replaced with rubber springs.

Eastern and North Eastern Regions.

Steam locomotives.

The adoption of ribbed section plates for laminated springs and Timmis section bars for helical springs have greatly reduced the number of spring failures.

The life of the springs has also been extended by the general adoption of rubber auxiliary springs referred to in Question 47.

Volute and torsion bar springs are not in use.

Carriages and wagons.

The failure of laminated and coiled bearing and bolster springs is not generally experienced.

Volute and torsion bar springs are not in use.

Western Region.

By using steel with closer carbon limitation than is permitted by the relevant British Standard Specifications and by the use of pyrometry controlled furnaces which maintain correct temperatures for hardening and tempering the springs, uniform springs are produced which vary little from the designed carrying capacity and stress. Modern springs have flat back plates and spring pads or location of the spring links and this arrangement eliminates failure of rolled or forged eyes which were hitherto experienced.

Southern Region.

Locomotives and other rolling stock.

Use types (*a*), (*b*) and (*c*). No special steps considered necessary.

Material and springs must comply with British Standard Specifications.

London Transport Executive.

(*a*) Shot peening of tension faces.

(*b*) All spiral springs of circular section are manufactured from ground bar, magnetically tested before coiling.

(*c*) These types of springs are not employed on L. T. E. railway rolling stock.

Victorian Railways, Australia.

(*a*) For laminated springs :

Back plates of springs are submitted to magnetic particles test for detection of flaws.

Each finished spring is subjected to :

(*i*) Scragging test : The spring shall not show any permanent set after the test load has been applied and released three times in rapid succession.

(ii) Deflection test : The specified working load is gradually applied and the loaded camber must not be less but may be up to 1/4″ over that specified. Stresses under working (static) load for carbon steel springs not to exceed :

30 T. P. S. I. for engine bogie and trailing truck;

28 T. P. S. I. for engine coupled underhung springs;

32 T. P. S. I. for engine coupled overhung springs;

35 T. P. S. I. for cars, vans, wagons, tram cars.

T. P. S. I. is tons (2 240 lbs.) per square inch.

(*b*) For helical springs :

Springs are cooled down after manufacture and afterwards hardened and tempered.

Each finished spring is subjected to :

(i) A scragging test : Spring is fully compressed by a quick acting scrag and the height measured after release. It shall then show no permanent set after scrag has been applied five times in rapid succession.

(ii) Deflection test : A sample spring to each new design is submitted to test and a load deflection graph obtained and forwarded to the rolling stock engineer for approval.

(*c*) Volute springs.

Volute springs limited to buffers and draw springs which are both obsolescent.

(*d*) For other types of springs (torsion bar, etc.).

None.

Ceylon Railways.

(*a*) (*b*) (*c*) (*d*) Modifying sections where found necessary.

Pennsylvania Railroad Co., U. S. A.

Methods used to reduce spring breakage are :

(*a*) Laminated spring life has been increased by enlarging and rounding the nib that holds the plates in proper relationship, careful heat treatment, and keeping the stresses within proper limits.

(*b*) Helical (spiral) spring life has been increased by careful heat treatment and keeping stresses within proper limits.

(*c*) and (*d*) Volute and torsion springs are not used on this railroad equipment.

Sudan Railways.

(*a*) Eliminating centre rivets and substituting nibbing and stud through top of buckle.

(*b*) Nil.

(*c*) Nil.

(*d*) Nil.

Indian Government Railways.

No reply.

New Zealand Government Railways.

Steam locomotives, rail cars, coaching and wagon stock.

Use coil and laminated springs. Design and specify coil springs for purchasing manufacture laminated springs. The failure of laminated springs has been investigated : the result should lessen the number of failures. Generally no trouble.

Multiple units.

Spiral springs on bolsters gave trouble due to overloading. The spring was strengthened by increasing the diameter of the metal, and this overcame the trouble.

South African Railways and Harbours.

All laminated springs scrag tested as laid down in specification No. C. M. E. 6/1949, clause (7) (E) (*).

Helical springs scragged « home » as laid down in specification No. C. M. E. 7 1945. clause 5 (E) (*).

Deflection under working load checked after scragging.

Volute springs only used in a few isolated cases.

Torsion bar springs not used.

(*) *Co-Reporters' comment :* Generally comply with British Standard Specification, Report No. 24, Part 3, for Carbon Steel Springs.

QUESTION 43.

Are these failures brought about by the quality of steel, the design of spring, or manufacturing processes (state especially if you use oil or water hardening steels and the results obtained in each case; state quality of steel used)? In those cases where the quality of steel is the cause, what arrangements have you adopted to ensure the consistent quality of steel? Attach specifications and state what steps you take to ensure the correct quality of steel being supplied.

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Failures may result from any of the causes named and also from corrosion of plates.

Both plain carbon, water hardened, and silico manganese, oil hardened, steels are used :

Chemical analysis of spring steel bars :

Quality	Type of spring	Chemical analysis				
		Car. %	Si. %	Mn. %	S. %	P. %
« B »	Carr.	.45/.55	—	.70 approx.	.05	.05
« C »	Wagon	.45/.55	—	.70 approx.	.06	.06
« E »	Silico manganese	.50/.60	1.8/2.0	.70/1.0	.05	.05

3 per cent of the bars subjected to cambering test. Scragging test for laminated springs:

All springs unless otherwise ordered shall be tested by being deflected in a steam press or other suitable scrag before the buckle has been put on by an amount equal to :

$$\frac{L^2}{1\,200\ t}$$

L = effective length of top plate in inches measured along the arc.

t = thickness of plate in inches.

Each spring shall withstand being deflected once to the specified amount, and must then withstand three further deflections in quick succession without showing any signs of failure or permanent set.

The scrag in which the springs are tested must be a quick-acting machine, capable of 70 strokes of 4 inches per minute.

Any spring standing under the specified height or more than 1/4 inch above the specified height will be rejected.

The springs will also be tested after the buckles have been fitted under varying loads to determine the range and deflection per ton. The Company's Inspector will select from the bulk up to 5 per cent. of the springs submitted for the purpose of the load test.

Springs found incapable of carrying the specified loads will be rejected.

The oil hardened steels are used for the more modern locomotives with higher axle loads, but the results are not markedly superior to those of water hardened steel used on the earlier classes.

A recent decision has been taken to use oil hardening carbon steel in lieu of silico-manganese steel as giving equal performance at a reduced cost.

Eastern and North Eastern Regions.

Attribute failures of locomotive springs almost entirely to the severity of the working conditions. As the road condition of the tracks has improved considerably in later years, spring failures have thereby been reduced.

Carriage springs are considered to work under more favourable conditions.

Laminated springs for all classes of rolling stock conform generally with British Standard Specifications, but carbon content is specified as under :

> The plates shall not show on analysis more than .85 per cent nor less than .75 per cent of carbon in the case of plates which are to be oil hardened, nor more than .55 per cent. nor less than .45 per cent in the case of plates which are to be water-hardened.

Buckles are of steel and where lugs are incorporated they are machined out of the solid.

Experience of oil-hardened springs has shown that they are softer and lose camber more than water-hardened springs; the tendency of plates to fracture seems to be less, Generally there is little to choose between the two methods of hardening the spring plates.

Western Region.

Experience has shown that if steel with wide range of carbon content is used and there is a variation, unsatisfactory springs may be produced.

Water hardened steel is used for all laminated springs and oil hardened steel for coil and volute springs.

Specifications :

Water hardened.

British Standard Report 24. Part 3. Specification 6x but with carbon content .5 to .55 % and manganese content .65 to .75 %.

Oil hardened.

British Standard Report 24. Part .3 Specification 7x but with carbon content .9 to 1.0 % and manganese content .6 to .7 %.

To ensure that correct steel is used a check analysis is taken from each cast of spring bar, whether for helical, volute or laminated spring.

Southern Region.

Locomotives and other rolling stock.

Material supplied to British Standard Specifications : manufacture of springs closely observed, and springs tested to Specification requirements. Designs checked and should working stresses be too high springs are redesigned to give longer life.

Spiral springs used for steam carriages and electric stock are designed to give low stress when « home » to ensure long life in service.

Both oil and water hardened steels are used.

London Transport Executive.

The few failures occurring may be attributable to any of the causes specified. Oil hardening silico-manganese steel is normaly used. Analysis is made of steel used in manufacture of springs and checks are made on the physical properties of each batch

of material supplied. The material is specified to be in accordance with British Standards Report No. 24. Specification 6 d.

Victorian Railways, Australia.

All three of the above factors have an influence on spring failures. Steel as supplied is not in all cases entirely free from defects. Special difficulty experienced in obtaining alloy steel bars free from longitudinal defects.

Design of springs constantly being improved. In the latest laminated springs for locomotives improvements have been made by eliminating forged eyes on back plates and substituting flat plates with slots and flat links with cotter and cotter seats. Riveting spring plates to buckle practically eliminated. Design cards control design of both laminated and helical springs for the best possible performance in service.

Faulty manufacturing processes contribute to spring failures e. g. incorrect heat treatment. Practice cards controlling spring manufacture, testing, and routine inspection issued to workshops for the guidance of all concerned. All plates of a laminated spring formed to the one radius to suit the free camber, this provides sufficient nip in the plates.

For carbon steel water hardening, and for silicon chrome steel oil hardening adopted. The results are satisfactory.

Quality of steel.

Carbon steel bars for laminated springs; manufactured from the highest quality steel made from selected material by the acid or basic open hearth or electric processes and steel to show a maximum Brinell hardness number of 228.

Carbon steel bars for volute and helical springs : manufactured from the highest quality steel made from selected material by the acid or basic open hearth or electric processes, and conforms to the analysis :

	Round bars for helical springs.	Flat bars for volute springs.
Carbon	0.90 to 1.05%	0.85 to 0.95%
Manganese ...	0.60 to 0.80%	0.55 to 0.70%
Sulphur Phosphorus	0.05% max.	0.05% max.

Silicon chrome alloy spring steel bars for helical and laminated springs are used on the « Spirit of Progress » Sydney Express Train, important cars and vans, certain express passenger locomotives and tenders. The permitted stress under static load is considerably higher than for carbon steel springs. The bars manufactured from the highest quality steel made from selected material by an approved process and to conform to the analysis :

	Minimum per cent	Maximum per cent
Carbon	0.47	0.56
Manganese	0.55	0.70
Chrome	0.60	0.80
Silicon............	1.20	1.60
Phosphorus Sulphur.	—	0.05

Quality of steel for laminated springs controlled by A. S. S. No. 3, 1938, which specifies that the steel when rolled must be smooth on its surface and free from cracks, ridges, scrappiness and defects of any kind. Limits of tolerance varies according to thickness from .015″ over to .010″ under, and according to width from .035″ over to .025″ under.

Up to 3 % of each cast shall be subjected to cambering test specified.

For round and other sections for helical spring limits of tolerance, as rolled, varies according to bar dimensions from .020″ over to .010″ under.

All alloy steel bars surface ground or alternatively shot or sand blasted, and visually inspected for defects. Only those bars passed used for the manufacture of springs.

Ceylon Railways.

Water hardening steels are used according to British Standard Specification.

Pennsylvania Railroad Co., U. S. A.

Oil is used for quenching springs. Carbon steel, having a carbon content of 0.90 to 1.05 %, is used for plates (or coils) and wrought iron or mild steel is used for the bands (buckles). Correct quality of steel is determined by inspection and analysis.

Sudan Railways.

(*a*) No. Springs generally give good service.

(*b*) Specification of laminated and helical springs.

Silico manganese — oil hardening — to British Standard Specification 24/6/D-1942.

(*c*) Until recently the specification was :

Silico manganese — water hardening — to British Standard Specification 24/6/D — 1942.

Indian Government Railways.

The design of springs meet load and service conditions. Failures generally attributed to faulty manufacture.

New Zealand Government Railways.

Steam locomotives and other rolling stock.

The quality of steel is not in dispute, being from reputable makers and in accordance with British Standard Specification. Carbon steel and silico-manganese steels are both used and as these require different heat treatment it is important that there should be no confusion as to which steel is being handled by the spring maker.

Failures are due more to wrong processes of spring manufacture than to any other cause.

The following recommendations have been made, although they have not yet been fully adopted.

1. All process work to be under the control of the laboratory which should institute :

a) continual random selection and testing of springs,

b) continual checking of pyrometers,

c) identity branding of springs.

2. Furnace work :

a) Plates to be heated to the requisite temperature, bent and set, then reheated to the correct temperature for quenching.

Bending, setting and quenching at one heat not to be permitted.

b) Continuous loading of furnace to be adopted. Plates to be removed as soon as possible after they have attained correct temperature.

Furnace control to be by means of continuous recording pyrometers.

c) Oil firing of furnace to be adjusted with a view to removing any tendency towards decarburisation of the spring metal.

d) Separate tempering baths required for carbon steel and silico-manganese steel, recording pyrometer controlled if possible.

Fitting.

a) « Regulator » method of fitting not approved.

b) All spring plates to be bent to correct radius of curvature, and subsequent fitting by hammering cold to be avoided.

c) Testing by scragging before buckling to be carried out.

d) Where springs are a bad shape under load when correctly fitted, matter to be represented for investigation of the design by the drawing office.

General.

a) All spring plates of Silico-manganese steel to bear an identity stamp.

b) All finished springs to bear a springmaker's identity stamp.

South African Railways and Harbours.

Failures are experienced due to varying factors.

Water hardening steel is used for laminated springs.

Oil hardening steel in used for helical springs.

Specifications Nos. C. M. E. 6/1949 and C. M. E. 7/1945 for spring steel for laminated and helical springs respectively, are attached.

Material is subjected to strict inspection during and after manufacture to ensure that it conforms to specification.

QUESTION 44.

Do you use special mounting arrangements in order to prevent movement not provided for (guiding, joints in the case of spiral springs, etc.)?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

No.

Eastern and North Eastern Regions

None other than centring studs for bolster springs.

Western Region.

With well made helical springs having ground bearing surfaces no special mounting arrangements are necessary.

Southern Region.

Locomotives, carriages and wagons.

No, but springs are located by recesses or spigots to ensure position and alignment.

Stops are provided in some instances to prevent springs going « home ».

No other guiding devices adopted.

London Transport Executive.

No.

Victorian Railways, Australia.

Guides are provided to control the lower end of helical springs on bogies for the « Spirit of Progress » Sydney Express Train, to prevent movement other than in the vertical direction.

Ceylan Railways.

No reply.

Pennsylvania Railroad Co., U. S. A.

Special guiding arrangements for springs are not used.

Sudan Railways.

No.

Indian Government Railways.

Nothing to report.

New Zealand Government Railways.

Steam locomotives and other rolling stock.

No.

South African Railways and Harbours.

Special mounting arrangements to prevent movement not usually provided for. Only used in isolated special instances.

QUESTION 45.

Are laminated spring buckles fitted hot or cold? State methods, process and results obtained?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

Earlier designs of springs have buckles fitted hot. Modern designs have buckles fitted cold with wedge and key fixing. No marked effect on the performance of the

springs, but life of buckle is longer when fitted cold and use of rivet avoided.

Coaching Stock.

All laminated carriage and wagon springs are buckled hot.

The spring plates which have previously been bolted together are placed in a vice and the bolt withdraw. The buckle is placed over the spring and a heated rivet inserted through the buckle spring and plates.

The buckling is completed in a two ram hydraulic buckling press and the rivet closed. Results are satisfactory.

Eastern and North Eastern Regions.

All buckles are pressed on hot by hydraulic pressure. Satisfactory results are obtained.

Western Region.

Laminated spring buckles are fitted hot and pressed in position by hydraulic press. Entirely satisfactory results are obtained by this method.

Southern Region.

Springs are hot buckled under hydraulic press. Good results.

London Transport Executive.

Laminated spring buckles are fitted hot and each leaf is « nibbed » to prevent longitudinal movement.

Victorian Railways, Australia.

Assembly of spring is as follows :

Each spring plate coated on the sides in contact with adjacent plates with a mixture of graphite and oil. Care taken to see that steps between plate ends are of uniform length and that no plates are skewed.

The steps between ends of spring plates vary not more than 1/8″ in length.

The buckles heated to between 880° and 920° C and lightly driven to their position central on the plates. The buckle then pressed up to the plates and held there until reasonably cool. Bottom of buckle must not be caulked or peaned.

The results quite satisfactory.

Ceylon Railways.

Hot pressed under hydraulic pressure.

Pennsylvania Railroad Co., U. S. A.

Laminated spring bands (buckles) are heated to forging temperature and applied by hydraulically pressing spring band against the plates.

Sudan Railways.

Hot. Close buckles under a press. Very good results are obtained.

Indian Government Railways.

Buckles fitted hot and method of fitting proved satisfactory.

New Zealand Government Railways.

Steam locomotives and other rolling stock.

Buckles fitted hot.

South African Railways and Harbours.

Spring buckles fitted hot. Spring plates at set, nipped up, etc., after heat treatment and tested for load and camber. Thereafter they are buckled in an hydraulic press. Results are good, and loose buckles very rare.

QUESTION 46.

What method do you use to prevent the buckle sliding longitudinally along the leaves, one in relation to the other?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

On hot buckled springs a centre rivet is

used. On cold buckled springs each plate is « nibbed » into the other and the whole secured by a wedge and key.

A method of suspension which discourages buckle shifting is that where the links or hangers are underhung, i. e. in tension. This has recently been refined by the introduction of an articulated joint between buckle and axlebox.

Coaching stock.

Spring plates and buckle are drilled or punched centrally and secured by a rivet.

Eastern and North Eastern Regions.

Centre circular and cotter shaped rivets fitted to all spring buckles.

Western Region.

Rivet is placed through buckle and spring plates.

Southern Region.

Locomotives.

Plates are nibbed and slotted with top plate by set screw through buckle, plates dented at centre of buckle.

Carriages and wagons.

Plates as for locomotives except for denting.

Rivet through buckle and plates.

London Transport Executive.

Laminated spring buckles are fitted hot and each leaf is « nibbed » to prevent longitudinal movement.

Victorian Railways, Australia.

Centre fastenings wherever practicable be the downward nib type. If bolts or rivets are unavoidable their diameter shall be 1/8″ of the width of spring plate but not more than 1/2″ and the hole not more than 9/16″ diameter. The holes for the bolt or rivet drilled.

The nib in the bottom plate engages in a hole centrally located in the buckle. For locomotive springs a set screw with end suitably rounded is screwed tightly through a tapped hole in the buckle through a hole in the upper dummy plate into the corresponding nib depression in the back plate. In general, for car elliptic springs the outer surface of the buckle itself is nibbed downwards while hot to engage in the nib recess in the back plate. No dummy plat is used.

Side play checks provided for springs over 36″ long. They are of the downward nib and slot type and commence at the third plate from the top and finish at the third plate from the bottom.

Ceylon Railways.

Nibs and/or set screws with packing plates.

Pennsylvania Railroad Co., U. S. A.

After the spring band is applied by hydraulic pressure, the band is cooled by immersing in oil which results in further tightening of the band on the plates due to band shrinkage.

Sudan Railways.

Nibbing, with a stud through top of buckles.

Indian Government Railways.

The springs nibbed in the centre and the buckle effectively secured to the plates, using a set-screw or a rivet.

New Zealand Government Railways.

Steam and electric locomotives, multiple units and rail cars.

Nibs, packing plate and set-screw.

Coaching and wagon stock, and rail cars.

Long rivet through buckle and leaves.

South African Railways and Harbours.

Spring plates nibbed at centre and hot pin rivetted in at top of buckle.

QUESTION 47.

Do you use rubber springs (for suspension, for shock and for drawgear, etc.)? What are the results obtained?

REPLIES.

BRITISH RAILWAYS.

London Midland Region.

Steam locomotives.

Yes. Rubber springs used extensively for drawgear with good results.

Also used in later designs of engine and tender spring suspension. Considered beneficial especially in conjunction with links having screw adjustment.

Coaching stock.

Rubber springs are used for all the purposes mentioned with satisfactory results.

Eastern and North Eastern Regions.

Yes.

Rubber springs used extensively in the buffing and draw gear of locomotives and other stock as auxiliaries to laminated and helical bearing springs.

Auxiliary springs have given a considerably increased life to the spring bolts to which they are fitted.

Rubber springs used in connection with carriage draw and buffing gear have proved most effective as a means of eliminating the noise, which is frequently associated with steel springs used in such places.

Western Region.

Auxiliary rubber bearing springs used on engines, carriage bogies and some freight stock. Rubber pad used on locomotive and carriage drawgear.

For wagon drawgear, both rubber and steel springs used. No conclusive evidence that rubber is superior to steel for wagon drawgear.

Southern Region.

Yes. Good results providing care is taken not to unduly stress the material by overloading.

London Transport Executive.

Rubber springs are used for some types of drawgear, buffing gear and suspension springs. No difficulty has been experienced in their use.

Victorian Railways, Australia.

Express passenger locomotives.

Reversing gear rod in some instances fitted with rubber shock absorbers.

On some rail motors a rubber cushioned wheel having a number of rubber blocks, between tyre and wheel centre have been tried, but they are obsolescent.

On bogies for the « Spirit of Progress » Sydney Express Train and similar cars, rubber pads under the side bearing helical springs and the side bearing rubbing blocks are used.

In addition on these cars sandwiched between a two piece bogie centre plate is a specially shaped Spencer Moulton pad having mild steel stabilising plates moulded into it.

Insulating bushes around the bolts securing the centre plate as well as the side bearing rubbing blocks are provided. Shore hardness of 50 is specified for all rubber components.

The use of these rubber blocks and rubber pads helps to reduce transmission of noise into the interior of steel cars.

Ceylon Railways.

Yes; very satisfactory.

Pennsylvania Railroad Co., U. S. A.

Rubber spring type draft gears are used extensively in passenger cars. Elimination of noise is the principal benefit.

Sudan Railways.

No. The climate is not considered suitable for rubber.

Indian Government Railways.

Rubber springs use din buffers of carriage and wagon stock draw gear and auxiliary springs of locomotives with entirely satisfactory results, and particularly as shock obsorbers reduce the failures of heavily stressed metallic parts under shock loads.

New Zealand Government Railways.

Steam locomotives and other rolling stock (as applicable), excluding wagons.

Buffers, drawn gear, auxiliary springs.

On « Eo » (Otira) locomotives we use rubber under the spring hangers. This has resulted in a reduction in the number of spring hanger failures on these locomotives.

Results very satisfactory.

Rail cars. (Additional uses.)

Engine mountings, bogie bolster centre mounting and float block mounting.

South African Railways and Harbours.

Rubber springs used for drawgear with satisfactory results. Also used for the motor nose suspension and spring hanger auxiliary springs on motor coaches.

SUMMARY OF REPLIES TO QUESTIONNAIRE.

A. GENERAL.

1. — The Regulations of the Administrations governing the maintenance and repair of rolling stock vary greatly in detail, but a common feature has emerged indicating that it is usually the condition of the tyres which determines the time in service. The wear on tyres has been variously expressed in terms of : mileage, time and actual amount of wear, and it is difficult to form any opinion which is the best basis.

The actual amount of wear would appear to be the most vital and practical, the other measures being adopted as the result of experience and peculiar to the Administrations' bureaucracy, with a view to keeping a uniform flow of work through the repair shops. The elasticity of the regulations in meeting the service demands on the stock is well exemplified by reference to the British Railways, and Victorian Railways, Australia.

2. — The majority view is that it has been found possible to increase modern rolling stock mileage, and the fitting of manganese steel liners to the axleboxes and horn guides has shown good results in the case of the British Railways, and where roller bearings are used reduction in maintenance is claimed. Alternatively, to mileage is the heavier and faster duty to which locomotives are subjected.

3. — There is an unanimous view of the expediency of applying the lessons learned as the result of experience to new stock, and repair of existing stock; such action with the latter being dependent on economic factors.

B. SOLID WHEELS.

4 to 10 (inclusive).

Each Administration has made use of solid rolled wheels and the range covers all phases of rolling stock. Against the advantages claimed, i. e. saving of weight, avoidance of loose tyres and lower costs, there are reports showing that there are considerations which affect the indiscriminate use of wheels of this type, and in this respect the working conditions would appear to be an influence.

It appears to be advantageous to use « one-wear » wheels on account of lower first cost. The use of power brakes on wagons and higher speed services may be expected to reduce the anticipated life of such wheels, with consequent earlier replacement. In such a case there may not be much difference in the real cost of « one-wear » solid versus « built-up » wheels. A suggestion for meeting this

contingency favourably in due course, is receiving the attention of the British Railways.

No speed limitations have been thought necessary for solid wheels and in respect of braking, providing cast iron brake shoes are used, their performance is satisfactory.

The physical characteristics for solid wheels are fairly uniform, and this remark also applies to the chemical analysis.

Concerning the manufacture of wheels with a view to obtaining appropriate characteristics on the different parts of the section, from the replies one concludes such control is left to the discretion of the manufacturers.

11 to 13 (inclusive).

As these questions are complimentary to each, the replies are co-ordinated. The general practice of the Administrations is to reprofile worn treads and flattened tyre surfaces by machining. An exception to this practice is that of the British Railways (London Midland Region), who claim economic advantages from depositing of metal at the roots of the wheel flanges, this departure from customary methods is unquestionably of interest.

The replies also indicate that the re-tyring of solid wheels is conditional with the design.

14. — It would appear that tread defects are likely to arise when :

a) The operating conditions demand high average speeds, heavy passenger loading and rapid braking frequently.

b) The type of brake blocks employed, i. e. cast iron or non-metallic brake blocks, also has an important bearing on this problem.

C. TYRED WHEELS.

15. — The quality of steel used by the Administrations is broadly similar for specific purposes, and is chosen presumably to achieve the mileage between repairs. Heat treatment of tyres is under manufacturer's control.

16. — Tyre shrinkage allowance varies and it is not possible to form any conclusions in regard to the stress imposed in the sections to prevent loose tyres, through lack of further information respecting diameters of wheels and section of material. It is the general view that there is a need for a high standard of tyre and wheel centre preparation for shrinkage of tyres and it would appear that careful technical consideration has been given to « Grip allowances » as affecting stress in the tyres. The diverse tyre expanding operations by electrical, gas heating and also coke firing are of interest.

17. — The duty imposed on the tyres influences their final thickness in service, but to what extent the views of the Administrations are in accord it is not possible to determine from the information supplied.

18. — The answer to the elimination of flats by welding is in the negative. Reprofiling both by grinding and turning methods are employed.

19. — Lubricators are used by some of the Administrations, but are generally of the rail type.

20 and 21. — The evidence here is somewhat contradictory, but on balance it would seem that lateral displacement of the axles does influence tyre wear.

22. — Experience, in this direction has been confined to British Railways and the New Zealand Government Railways; the former reporting satisfactory results, the latter the reverse.

D. AXLEBOXES.

a) Roller bearing boxes.

23 and 24. — Considerable experience in the use of roller bearing boxes has been gained by some of the Administrations, who have furnished data regarding their reliability and attention required in service. The details of performance will be seen on reference to answers to questionnaire.

25 and 26. — The types of roller bearings employed are diverse, and no doubt usage

will determine the best to adopt for rolling stock.

27. — The technical character of this question and replies calls for no special comment.

28. — The answers to this question by the Administrations are comprehensive and would appear adequate.

29. — The necessity for preventing current passing through the roller bearings is determined by the electrical conditions prevailing.

b) Axleboxes with bearing or brasses other than ordinary axleboxes with oil pads or packing.

30 and 31. — The general practice is to use ordinary axleboxes. The British Railways (Southern Region), have used successfully for more than 25 years axleboxes incorporating a thrust pad on the covers of motor bogie axleboxes, of its multiple unit stock. It is now in course of changing over to this practice for its express electric stock, motor bogies which were built with collars on the axle journals. Reason for change — very heavy thrust wear experienced on both journal collars and bearings. The ordinary axleboxes are oil lubricated.

32. — Generally the Administrations have little to report, using apparently axleboxes of conventional designs. A marked departure in respect of wagon axleboxes was approved by British Railways (Railway Clearing House) in so far that new designs of axleboxes need no longer be fitted with dust shields. Shields are frequently found broken and useless after relatively short service, and experience has shown they can be eliminated successfully. The cleanliness of the interior of the boxes and their running performance is at least equal to dust shield fitted boxes. These results may be due to the favourable conditions of humidity which usually prevail in Great Britain.

c) Improvements to ordinary axleboxes with bearings and brasses.

33. — Nothing special to report; there has been some active steps taken by the British Railways to improve locomotives in this respect.

34. — The analysis of antifriction metals indicates there is no decided preference to use an alloy with a rich tin content except for locomotives; and special high speed coaching stock.

35. — The replies indicate the genera- appreciation of the need for careful preparal tion of the bearings before turning, pouring temperatures of the alloy, etc.

A matter of interest is that British Railways were compelled through the shortage of tin and lead during the world war, to reduce the thickness of white metal linings for carriage and wagon bearings, the results were satisfactory and the practice still continues.

d) Present practice in the choice of the type of box.

36. — Three Administrations have formed definite views in favour of the modern roller bearing axleboxes usually for operating reasons, others still stand by axleboxes produced as in earlier generations. The economics of the matter would seem to favour the latter, but obviously from the data supplied it is now open to question.

E. WEARING AND FRICTION METALS

37 to 39 (inclusive).

As stated earlier wheel tyres hold the dominant position time rolling stock is out of service; but other contributory causes indicate where attention to detail would seem to be worthwhile. Employment of manganese, fabricated materials case hardened bushes, etc., to give greater working life to details is general. It is somewhat surprising that few Administrations have commented on the recovery of parts by welding, usually a most economic procedure.

40. — Exploration into new fields under this heading would appear to be confined to British Railways (London Transport Executive).

41. — There is a movement from set forms of adjustment — see Pennsylvania Railroad Co. reply.

F. SPRINGS.

42 to 46 (inclusive).

Careful attention to manufacture, the choice of material low stress limits and compliance with specifications would appear to be the best safeguards against spring fractures. There appears to be little to choose in performance whether springs are water or oil hardened.

Respecting devices to prevent movement only one Administration, i. e. Victorian Railways, Australia appears to have considered such provision necessary. The practice of hot buckling springs and riveting of the plates in the buckles is the practice generally. Nibbing is also resorted to keep plates in alignment.

47. — The employment of rubber springs for the purposes defined in the question is generally satisfactory.

M. WEISSENBRUCH & Co. Ltd.
Printer to the King.
(Manag. Dir.: P. de Weissenbruch,
238, chaussée de Vleurgat, XL.)

Edit. responsible : P. Ghilain
108, rue Général Gratry, Schaerbeek.

PRINTED IN BELGIUM